

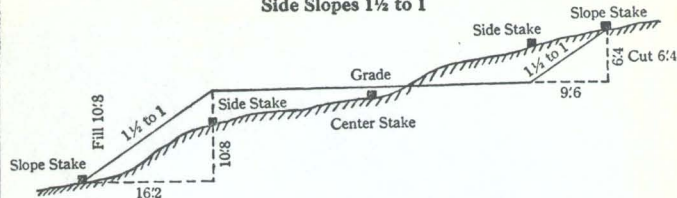
406

Black Hawk Co.
Proj. 5-2886(6)

SECTION 4

Book 2 of 2

DISTANCES FROM SIDE STAKES FOR CROSS-SECTIONING Roadway of any Width Side Slopes 1½ to 1



In the figure above: Opposite 6 under "Cut or Fill" and under .4 read 9/6 the distance from the side stake to the slope stake at right. Opposite 10 under "Cut or Fill" and under .8 read 16/2, the distance from the side stake to the slope stake at the left.

Cut or Fill	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Cut or Fill
	Distance out from Side or Shoulder Stake										
0	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	0
1	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	1
2	3.0	3.2	3.3	3.5	3.6	3.8	3.9	4.1	4.2	4.4	2
3	4.5	4.7	4.8	5.0	5.1	5.3	5.4	5.6	5.7	5.9	3
4	6.0	6.2	6.3	6.5	6.6	6.8	6.9	7.1	7.2	7.4	4
5	7.5	7.7	7.8	8.0	8.1	8.3	8.4	8.6	8.7	8.9	5
6	9.0	9.2	9.3	9.5	9.6	9.8	9.9	10.1	10.2	10.4	6
7	10.5	10.7	10.8	11.0	11.1	11.3	11.4	11.6	11.7	11.9	7
8	12.0	12.2	12.3	12.5	12.6	12.8	12.9	13.1	13.2	13.4	8
9	13.5	13.7	13.8	14.0	14.1	14.3	14.4	14.6	14.7	14.9	9
10	15.0	15.2	15.3	15.5	15.6	15.8	15.9	16.1	16.2	16.4	10
11	16.5	16.7	16.8	17.0	17.1	17.3	17.4	17.6	17.7	17.9	11
12	18.0	18.2	18.3	18.5	18.6	18.8	18.9	19.1	19.2	19.4	12
13	19.5	19.7	19.8	20.0	20.1	20.3	20.4	20.6	20.7	20.9	13
14	21.0	21.2	21.3	21.5	21.6	21.8	21.9	22.1	22.2	22.4	14
15	22.5	22.7	22.8	23.0	23.1	23.3	23.4	23.6	23.7	23.9	15
16	24.0	24.2	24.3	24.5	24.6	24.8	24.9	25.1	25.2	25.4	16
17	25.5	25.7	25.8	26.0	26.1	26.3	26.4	26.6	26.7	26.9	17
18	27.0	27.2	27.3	27.5	27.6	27.8	27.9	28.1	28.2	28.4	18
19	28.5	28.7	28.8	29.0	29.1	29.3	29.4	29.6	29.7	29.9	19
20	30.0	30.2	30.3	30.5	30.6	30.8	30.9	31.1	31.2	31.4	20
21	31.5	31.7	31.8	32.0	32.1	32.3	32.4	32.6	32.7	32.9	21
22	33.0	33.2	33.3	33.5	33.6	33.8	33.9	34.1	34.2	34.4	22
23	34.5	34.7	34.8	35.0	35.1	35.3	35.4	35.6	35.7	35.9	23
24	36.0	36.2	36.3	36.5	36.6	36.8	36.9	37.1	37.2	37.4	24
25	37.5	37.7	37.8	38.0	38.1	38.3	38.4	38.6	38.7	38.9	25
26	39.0	39.2	39.3	39.5	39.6	39.8	39.9	40.1	40.2	40.4	26
27	40.5	40.7	40.8	41.0	41.1	41.3	41.4	41.6	41.7	41.9	27
28	42.0	42.2	42.3	42.5	42.6	42.8	42.9	43.1	43.2	43.4	28
29	43.5	43.7	43.8	44.0	44.1	44.3	44.4	44.6	44.7	44.9	29
30	45.0	45.2	45.3	45.5	45.6	45.8	45.9	46.1	46.2	46.4	30
31	46.5	46.7	46.8	47.0	47.1	47.3	47.4	47.6	47.7	47.9	31
32	48.0	48.2	48.3	48.5	48.6	48.8	48.9	49.1	49.2	49.4	32
33	49.5	49.7	49.8	50.0	50.1	50.3	50.4	50.6	50.7	50.9	33
34	51.0	51.2	51.3	51.5	51.6	51.8	51.9	52.1	52.2	52.4	34
35	52.5	52.7	52.8	53.0	53.1	53.3	53.4	53.6	53.7	53.9	35
36	54.0	54.2	54.3	54.5	54.6	54.8	54.9	55.1	55.2	55.4	36
37	55.5	55.7	55.8	56.0	56.1	56.3	56.4	56.6	56.7	56.9	37
38	57.0	57.2	57.3	57.5	57.6	57.8	57.9	58.1	58.2	58.4	38
39	58.5	58.7	58.8	59.0	59.1	59.3	59.4	59.6	59.7	59.9	39
40	60.0	60.2	60.3	60.5	60.6	60.8	60.9	61.1	61.2	61.4	40

EUGENE DIETZGEN CO.

V. OPER. 11
APR 28 1972

Property of Black Hawk Co.

Proj S. 2888 (8)--50-7

Address Waterloo, Iowa

**BLACK HAWK COUNTY
ENGINEER'S OFFICE
COURT HOUSE
WATERLOO, IOWA 50703**

Phone _____

Charge Code 66-07

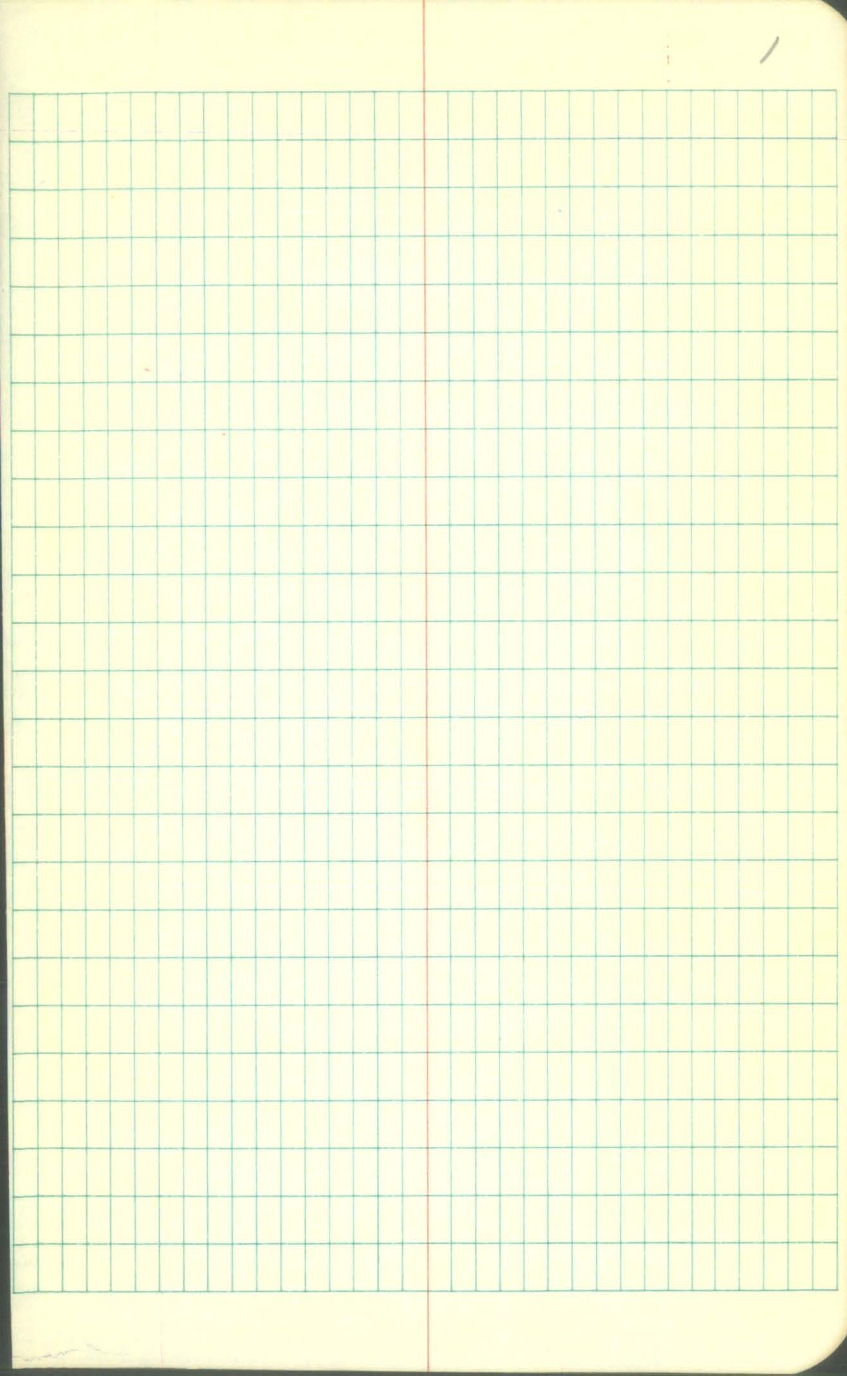
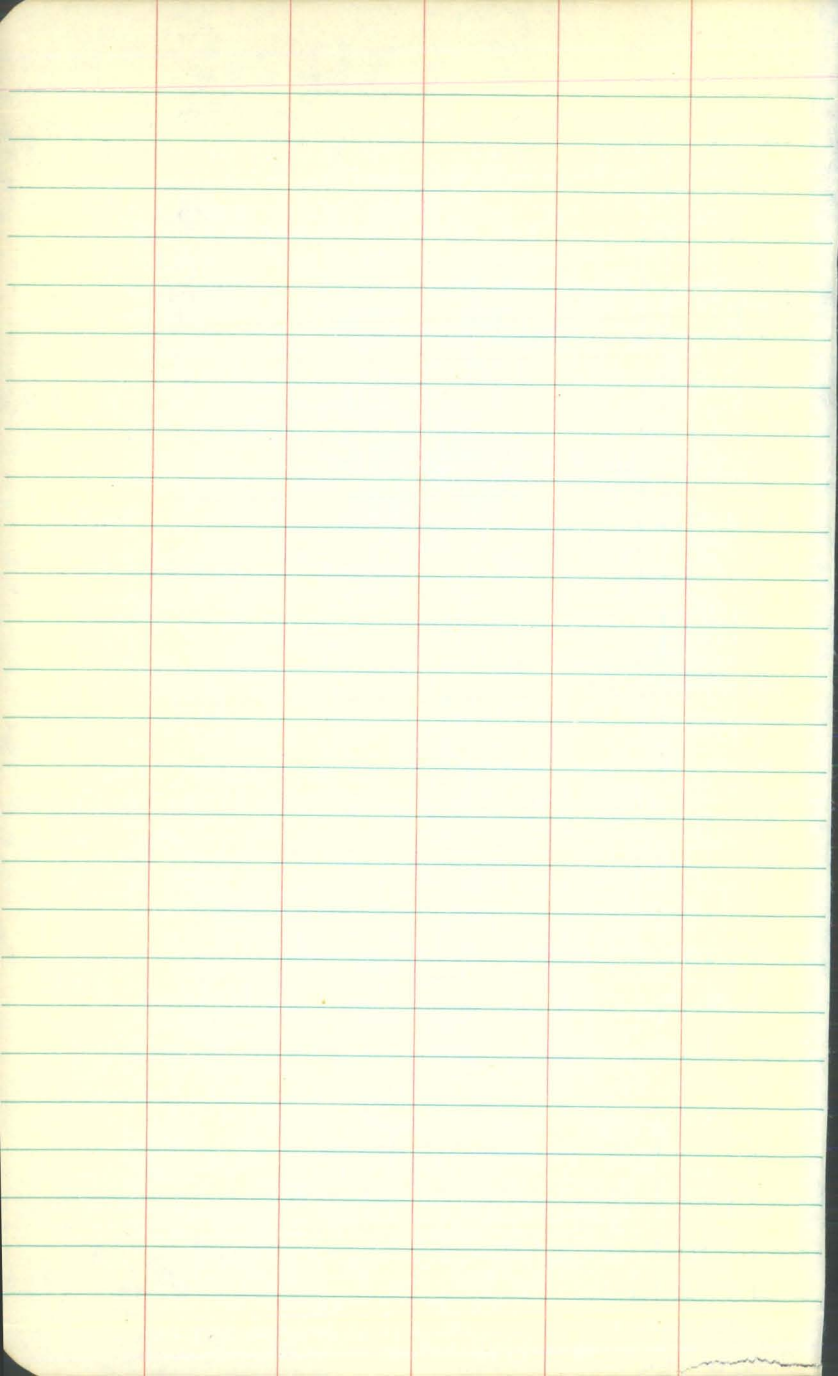
KP OPER. 7
APR 28 1972

This Field Book is manufactured of a High Grade 50% Rag Paper having a WATER RESISTING SURFACE, and is sewed with Bing Special Enamel Waterproof thread.

Made in U. S. A.

A

WATERLOO, IOWA 50703
COURT HOUSE
ENGINEER'S OFFICE
BLACK HAWK COUNTY



1972

341+00

+50

340+00

+50

339+00

+50

338+00

+50

337+00

+50

336+00

335+59 East end of bridge

B.M. 7.20 929.48 922.28 922.31

Short Key Punch

Hub

11'

♀

11'

Hub

4

1.84

1.5

1.2

1.5

1.77

2.55

2.2

1.8

2.1

2.41

2.93

2.8

2.4

2.6

2.77

3.75

3.5

3.1

3.3

3.53

4.64

4.3

3.9

4.2

4.48

5.49

5.1

4.7

5.0

5.24

6.06

5.9

5.4

5.7

5.92

6.62

6.5

6.1

6.5

6.66

7.53

7.1

6.7

7.1

7.38

7.9

7.6

7.2

7.5

7.80

7.72

7.5

7.2

7.4

7.62

7.15

7.15

6.97

7.16

7.16

Brass plate in N.W. Cor. bridge floor sta 335+38

+50
Hub Lt ϕ 13.89 951.40
951.38 1.64 939.49

347+00

+50

346+00

+50

345+00

+50

344+00

+50

343+00

+50

342+50

+50

342+00

Hub Lt ϕ 10.87 939.13 1.22 928.26

341+50

Hub ~~11'~~ 11' 11' Hub 5
12.43 12.1 11.8 12.0 12.19

1.64 1.4 1.1 1.3 1.52

2.78 2.8 2.6 2.8 3.03

4.16 4.1 3.8 4.1 4.27

5.16 4.9 4.7 5.0 5.15

6.05 5.8 5.4 5.8 6.06

6.80 6.6 6.1 6.4 6.61

7.43 7.3 6.9 7.2 7.33

8.21 8.0 7.6 7.9 8.23

8.99 8.7 8.2 8.6
8.57 8.86

9.53 9.4 8.9 9.2 9.48

10.21 10.1 9.6 9.8 10.04

1.22 0.9 0.5 0.8 0.94

+43

352+18

+93

+68

P.C. +43

351+00

Hub H₇ Φ

14.24

963.84

~~963.80~~

1.82

949.56

+50

350+00

+50

349+00

+50

348+00

Hub

11'

♀

11'

Hub

6

7.55

7.4

7.0

7.2

7.37

8.04

8.1

7.8

8.0

8.12

8.92

8.9

8.6

8.8

8.91

10.12

9.8

9.4

9.7

9.79

10.93

10.7

10.3

10.6

10.69

12.36

12.3

11.8

12.0

12.17

1.82

1.7

1.2

1.4

1.53

3.62

3.5

3.0

3.2

3.28

5.42

5.2

5.0

5.1

5.34

7.13

7.1

6.8

6.9

11.01

8.99

8.8

8.5

8.6

8.81

10.71

10.5

10.2

10.4

10.43

355+35

355+13

355+01

~~43~~

+68

+43

354+18

+93

+68

+43

353+18

+93

352+68

Hub

3.12

~~3.12~~

11'

3.1

4

3.0

11'

3.4

Hub

3.78

7

3.20

3.3

3.0

3.5

3.94

3.41

3.5

3.2

3.6

3.88

3.81

3.7

3.3

3.5

3.72

3.94

3.9

3.4

3.5

3.50

4.31

4.2

3.8

3.7

3.69

4.64

4.5

4.1

4.2

4.34

5.18

5.0

4.6

4.8

4.97

5.57

5.6

5.1

5.4

5.48

6.07

6.1

5.7

6.0

6.08

6.88

6.7

6.3

6.5

6.71

+35

358+10

+85

+60

B.M. 12.09 970.89 5.05 958.75 958.80

+35

357+10

+85

+60

+35

356+10

+85

355+60

Hub

11'

♀

11'

Hub

8

10.82

10.3

9.7

10.2

10.84

11.04

10.4

9.9

10.4

10.97

10.73

10.3

9.9

10.3

10.68

10.22

10.2

10.0

10.2

10.36

Valve in Power Pole 50' Lt sta 357+18

3.50

3.3

3.2

3.4

3.75

3.69

3.7

3.3

3.9

4.15

3.85

3.8

3.4

3.9

4.21

3.79

3.6

3.4

3.8

4.22

3.53

3.4

3.3

3.7

4.04

3.58

3.4

3.1

3.6

3.92

3.47

3.3

3.1

3.3

3.91

3.51

3.2

3.0

3.4

3.83

364+00

+50

Hub L+7 12.04 981.45 1.48 969.41

363+00

+50

362+00

361+50

361+00

+50

360+00

360+50

359+00

PT
358+60

Hub	11'	♀	11'	Hub ⁹
9.96	9.5	9.1	9.5	10.18
11.01	10.4	10.0	10.5	11.17
1.48	0.9	0.4	1.0	1.54
2.44	1.9	1.4	1.9	2.37
3.35	2.9	2.4	2.9	3.44
4.38	3.9	3.4	3.9	4.39
5.45	5.0	4.6	5.0	5.54
6.68	6.2	5.8	6.2	6.81
7.94	7.5	7.0	7.4 7.4	8.02
9.1	8.6	8.1	8.6	9.14
9.98	9.4	9.0	9.4	9.93 10.73
10.44	10.0	9.6	9.9	10.56

+50

370+00

+50

369+00

+50

368+00

+50

367+00

+50

366+00

+50

365+00

364+50

Hub

11'

♀

11'

Hub¹⁰

5.46

5.0

4.7

5.1

5.69

4.95

4.4

4.1

4.5

4.85

4.58

4.1

3.7

4.1

4.46

4.39

3.8

3.5

3.8

4.32

4.38

3.7

3.4

3.8

4.27

4.34

3.8

3.4

3.8

4.40

4.48

4.0

3.6

4.0

4.55

4.78

4.3

3.9

4.4

4.97

5.37

4.9

4.5

4.9

5.47

6.22

5.6

5.4

5.8

6.34

7.18

6.6

6.3

6.8

7.36

8.24

7.7

7.2

7.8

8.30

9.15

8.5

8.1

8.7

9.30

+50

376+00

+50

375+00

+50

374+00

+50

373+00

+50

372+00

+50

371+00

Hub Lt.
Sta. 370+50

0.98

976.97

5.46

975.99

8.45

7.9

7.5

8.0

8.50

8.27

7.8

7.4

7.8

8.37

8.08

7.5

7.0

7.4

7.80

7.58

7.0

6.6

7.0

7.57
~~5.5~~

7.08

6.6

6.2

6.7

7.31

6.44

6.0

5.5

6.0

6.51

5.69

5.2

4.7

5.3

5.60

5.04

4.4

4.0

4.5

4.92

4.22

3.7

3.2

3.7

4.15

2.48

2.9

2.5

2.9

3.29

2.66

2.1

1.7

2.1

2.41

1.92

1.3

0.9

1.4

2.02

+50

382+00

+50

381+00

+50

380+00

+50

379+00

+50

378+00

Hub Lt ϕ 8.44 976.85 8.56 968.41

+50

377+00

2.32

1.8

1.3

1.9

2.23

3.04

2.5

2.1

2.7

2.96

3.77

3.3

2.9

3.5

3.74

4.62

4.2

3.6

4.2

4.63

5.32

4.9

4.5

5.0

5.32

6.10

5.6

5.2

5.6

6.00

6.81

6.2

5.9

6.3

6.71

7.37

6.8

6.4

6.8

7.20

7.86

7.3

6.8

7.2

7.49

8.17

7.5

7.2

7.5

7.92

8.56

7.8

7.5

7.9

8.33

8.55

7.9

7.6

8.0

8.56

+50

388+00

+50

387+00

+50

386+00

+50

385+00

+50

B.M.

7.00 978.90 978.92

384+00

+50

Hub ϕ

10.64

895.90

1.59

975.26 ✓

383+00

13

3.54

3.1

2.5

3.1

3.45

3.77

3.3

3.0

3.3

3.60

4.32

3.7

3.3

3.7

3.97

4.77

4.2

3.7

4.2

4.51

5.28

4.8

4.3

4.8

5.25

5.93

5.4

5.0

5.4

5.89

6.59

6.1

5.6

6.1

6.58

7.37

6.9

6.4

6.9

7.23

8.06

7.6

7.2

7.6

7.91

spt in stump 54' Rt Sta 384+05

8.84

8.3

7.9

8.3

8.49

Pin

9.75

9.2

8.8

9.3

9.68

1.59

1.59

1.0

0.6

1.2

1.52

+50

394+00

+50

393+00

+50

392+00

+50

391+00

Hub Lt. ϕ 5.30 988.72 2.48 983.42

+50

390+00

+50

389+00

14

5.37 4.8 4.3 4.8 5.27

5.28 4.8 4.2 4.8 5.15

5.20 4.7 4.3 4.7 5.20

5.17 4.7 4.3 4.7 5.04

5.09 4.7 4.3 4.8 5.03

5.18 4.7 4.3 4.8 5.06

5.23 4.8 4.3 4.8 5.08

5.36 5.0 4.4 4.9 5.26

2.48 $\frac{2.1}{1.5}$ 1.5 2.1 2.56

2.63 2.2 1.6 2.3 2.73

2.79 2.4 1.8 2.5 2.89

3.14 2.6 2.1 2.7 3.06

+50

400+00

+50

399+00

+50

398+00

+50

Hub Lt ↓ ϕ 5.55 988.74 5.53 983.19

397+00

+50

396+00

+50

395+00

15

5.12 4.8 4.2 4.7 5.04

5.11 4.8 4.2 4.7 5.12

5.13 4.7 4.3 4.8 5.16

5.10 4.8 4.3 4.8 5.22

5.00 4.7 4.4 4.9 5.18

5.18 4.8 4.5 4.9 5.17

5.32 4.9 4.5 4.9 5.26

5.53 5.0 4.6 5.0 5.45

5.52 5.1 4.5 5.0 5.36

5.50 5.1 4.5 5.0 5.29

5.43 5.0 4.4 4.9 5.18

5.32 4.8 4.4 4.8 5.31

+50

406+00

+50

405+00

+50

404+00

Hubbly ϕ 5.01 988.84 4.91 983.83

+50

403+00

+50

402+00

+50

401+00

4.80 4.3 3.7 4.5 4.91

4.64 4.1 4.37 4.4 4.79

4.58 4.1 3.6 4.2 4.68

4.61 4.2 3.6 4.2 4.80

4.66 4.3 3.7 4.3 4.72

4.84 4.4 3.9 4.3 4.70

4.91 4.5 3.8 4.4 4.77

4.83 4.5 4.0 4.4 4.85

4.84 4.5 3.9 4.3 4.82

4.88 4.5 4.0 4.4 4.80

5.04 4.6 4.0 4.5 4.99

5.14 4.5 4.1 4.6 5.01

410+12
Hub Lt ϕ 1.64 981.66 8.82 980+02

+87

+62

+37

409+12

+87

+62

+37

408+12

P.C.
407+87

+50

407+00

1.74 1.4 1.2 1.5 1.78

8.82 8.4 8.0 8.4 8.84

spk in Pa. Po 135' Lt sta. 410+03

8.38 8.0 7.4 7.8 8.27

7.68 7.3 6.9 7.3 7.67

7.05 6.7 6.4 6.9 7.28

6.66 6.4 6.0 6.4 6.83

6.35 6.0 ~~5.5~~ 6.0 6.47

6.07 5.6 5.1 5.7 6.16

5.71 5.3 4.8 5.4 5.74

5.43 5.0 4.5 5.1 5.57

5.22 4.7 4.2 4.8 5.26

5.00 4.5 3.9 4.6 4.96

413+00

PT

+87

+62

+37

412+12

+87

+62

+37

411 +12

+87

+62

410+37

10.20

9.7

9.2

9.7

10.18

9.70

9.3

8.9

9.3

9.76

8.97

8.5

8.2

8.5

8.98

8.20

7.8

7.4

7.9

8.26

7.45

7.0

6.6

7.2

7.56

6.79

6.4

6.0

6.5

7.04

6.12

5.7

5.3

5.8

6.15

5.45

5.0

4.6

5.1

5.61

4.82

4.4

4.0

4.5

4.92

4.04

3.6

3.3

3.8

4.03

3.04

2.6

2.5

2.7

3.98

1.82

1.7

1.6

1.7

1.65

+50

419+00

+50

418+00

+50

417+00

+50

416+00

+50

415+00

Hub Lt. 0.28 967.43 14.51 967.15

+50

~~X~~~~14.51 967.15~~

414+00

413+50

6.45

6.1

5.6

6.1

6.41

6.34

6.1

5.6

6.1

6.58

6.14

5.9

5.4

5.9

6.56

6.12

5.6

5.2

5.7

6.26

5.44

5.1

4.7

5.3

5.87

4.98

4.6

4.1

4.6

5.31

4.26

3.9

3.5

4.0

4.44

3.70

3.3

2.8

3.3

3.84

2.90

2.3

1.9

2.3

2.74

1.63

1.2

0.7

1.2

1.44

14.51

14.0

13.6

14.1

14.47

12.95

12.5

12.1

12.7

13.16

11.60

11.1

10.7

11.2

11.75

+50

425+00

+50

424+00

+50

423+00

+50

422+00

+50

Hub 47 ϕ 8.92 970.97 5.38 962.05
 ↓
 421+00

+50

420+00

Hub

11'

2

11'

Hub 20

3.36

3.0

2.7

3.1

3.61

3.90

3.6

3.4

3.8

4.27

4.52

4.3

3.8

4.5

5.03

5.27

4.9

4.5

5.0

5.22

5.66

5.3

 $\frac{5.0}{5.5}$
~~5.5~~
 $\frac{5.5}{5.54}$

5.97

6.18

5.7

5.6

6.2

6.35

7.23

6.7

6.3

6.8

7.46

7.76

7.3

7.0

7.4

8.02

8.31

8.0

7.7

8.0

8.60

5.38

5.1

4.8

5.1

5.62

6.00

5.6

5.3

5.6

6.03

6.28

5.9

5.4

5.9

6.33

+50

431+00

+50

430+00

+50

429+00

+50

428+00

+50

Hub L₇ Φ 9.86 979.61 1.22 969.75

427+00

+50

426+00

1.88

1.5

1.3

1.7

2.18

3.11

2.7

2.5

2.8

3.24

4.38

3.9

3.5

3.9

4.27

5.42

4.9

4.6

5.0

5.59

6.28

5.8

5.5

6.0

6.31

7.10

6.7

6.3

6.9

7.38

8.08

7.5

7.1

7.7

8.21

8.69

8.2

7.8

8.4

8.97

9.26

8.9

8.5

9.1

9.62

1.22

0.9

0.5

1.2

1.54

2.05

1.7

1.3

1.8

2.32

2.76

2.4

2.0

2.5

3.15

+50

437+00

+50

436+00

+50

435+00

+50

434+00

+50

433+00

+50

Hub Lt ϕ 10.94 989.25 0.70 978.91
 432+00

4.73

4.4

4.2

4.6

4.79

4.43

4.1

3.9

4.3

4.22

4.33

4.1

3.8

4.4

4.84

4.49

4.2

3.9

4.4

4.92

4.77

4.4

4.2

4.5

4.78

5.39

5.0

4.7

4.8

5.24

6.22

5.9

5.5

5.9

6.33

7.11

6.8

6.6

7.1

7.49

8.13

7.7

7.5

8.0

8.46

9.17

8.7

8.5

8.9

9.30

~~10~~

10.00

9.7

9.5

10.0

10.46

0.70

0.5

0.2

0.7

1.32

Hub Lt ϕ 0.97 974.78 13.99 973.81

+50

443+00

+50

442+00

+50

441+00

+50

440+00

+50

439+00

+50

438+00

Bm 2.61 984.80 4.66 985.19

23

13.99 13.7 13.5 13.8 14.25

12.96 12.7 12.4 12.7 13.18

11.85 11.5 11.4 11.7 12.13

10.82 10.5 10.1 10.6 11.07

9.91 9.5 9.2 9.7 10.21

8.93 8.5 8.2 8.7 9.27

7.93 7.5 7.2 7.6 7.98

7.03 6.6 6.3 6.7 7.00

6.13 5.5 5.2 5.8 6.28

5.11 4.6 4.4 4.8 5.39

4.23 3.9 3.6 4.0 4.50

3.56 3.1 2.8 3.2 3.70

spt in Pa Pa 30' Pt. sta. 439+70 New Bench

+50

449+00

+50

448+00

+50

447+00

+50

446+00

+50

445+00

+50

444+00

13.13

12.8

12.4

12.8

13.27

12.19

11.8

11.4

11.8

12.38

11.27

10.9

10.4

10.9

11.67

10.34

10.6

9.5

9.9

10.37

9.28

8.9

8.5

8.9

9.33

8.24

7.8

7.5

7.8

8.32

7.13

6.8

6.4

6.8

7.38

6.11

5.7

5.4

5.8

6.26

5.05

4.6

4.4

4.7

5.19

4.04

3.6

3.2

3.6

4.12

2.87

2.5

2.2

2.7

3.20

1.98

1.6

1.4

1.7

2.11

+50

455+00

+50

454+00

+50

453+00

+50

452+00

+50

451+00

+50

Hub L₇ 1.61 962.19 14.20 960.58

450+00

9.24

8.7

8.1

8.8

9.28

8.86

8.3

7.8

8.3

8.86

8.46

7.9

7.3

7.8

8.56

7.74

7.5

7.1

7.5

8.03

7.32

6.9

6.6

7.0

7.68

6.75

6.4

5.8

6.3

6.86

6.05

5.7

5.4

5.9

6.42

5.53

~~5.0~~
5.0

4.6

5.1

5.52

4.47

4.1

3.8

4.2

4.63

3.54

3.3

2.8

3.2

3.63

2.79

2.3

1.8

2.3

2.75

14.20

13.8

13.4

13.9

14.46

+50

461+00

+50

460+00

+50

459+00

+50

458+00

+50

Hub Lt ϕ 7.80 960.44 9.55 952.64

457+00

+50

456+00

4.94

4.6

4.2

4.7

5.30

5.74

5.0

4.6

5.3

5.78

6.31

5.6

5.0

5.7

6.24

6.57

5.9

5.3

6.1

6.65

6.91

6.2

5.7

6.4

6.86

7.05

6.4

5.8

6.5

7.03

7.07

6.3

5.8

6.5

6.95

7.15

6.4

5.9

6.5

7.17

7.43

6.8

6.3

6.8

7.52

9.55

9.0

8.4

9.0

9.56

9.55

9.1

8.6

9.0

9.77

9.58

9.0

8.5

9.0

9.54

6.05 954.39 954.53

Stop Key Punch.

467.2 edge of slab

+50

463+00

+50

462+00

Hub 11' ♀ 11' Hub 27

+ in East Hdwl Box Culv. 420' North of sta 463+28

2.31 2.31 2.20 2.13 2.13

2.81 2.6 2.3 2.3 2.54

3.64 3.1 2.5 2.9 3.32

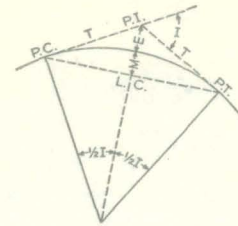
4.20 3.9 3.0 3.6 3.96

4.93 4.3 3.8 4.3 4.89

28-End

CURVE AND REDUCTION TABLES

Published by Eugene Dietzgen Co.



CURVE FORMULAS

1. Radius : $R = \frac{50}{\sin D/2}$
2. Degree of Curve: $D = 100 \frac{I}{L}$. Also, $\sin D/2 = \frac{50}{R}$
3. Tangent : $T = R \tan \frac{1}{2} I$. Also, $T = \frac{T \text{ for } 1^\circ \text{ curve}}{D} + C$.
4. Length of Curve: $L = 100 \frac{I}{D}$
5. Long Chord : $L.C. = 2R \sin \frac{1}{2} I$.
6. Middle Ordinate: $M = R (1 - \cos \frac{1}{2} I)$
7. External : $E = \frac{R}{\cos \frac{1}{2} I} - R$. Also, $E = T \tan \frac{1}{4} I$.

EXPLANATION AND USE OF TABLES

Given P.I. Sta. 83+40.7, $I = 45^\circ 20'$ and $D = 6^\circ 30'$ find:

Stations—P.C. = P.I. - T. $T = \frac{T \text{ for } 1^\circ \text{ Curve}}{D} + C$. From Tables V and VI

$$T = \frac{2392.8}{6.5} + .197 = 368.32 = 3 + 68.32. \text{ Sta. P. C.} = 83 + 40.7 - (3 + 68.32) = 79 + 72.38.$$

$$P. T. = P. C. + L, \text{ and } L = 100 \frac{I}{D} = 100 \frac{45.33}{6.5} = 697.38 \text{ Therefore, } P. T. = (79 + 72.38) + (6 + 97.38) = 86 + 69.76.$$

Offsets—Tangent offsets vary (approximately) directly with D and with the square of the distance. From Table III Tangent Offset for 100 feet = 5.669 feet. Distance = 80 - Sta. P. C. = 27.62. Hence offset = $5.66 \times \left(\frac{27.62}{100}\right)^2 = .432$ ft. Also, square of any distance, divided by twice the radius equals (approximately) the distance from tangent to curve. Thus $(27.62)^2 \div (2 \times 881.95) = .432$ ft.

Deflections—Deflection angle = $\frac{1}{2} D$ for 100 ft., $\frac{1}{4} D$ for 50 ft., etc. For "X" ft., Deflection Angle (in minutes) = $.3 \times X \times D$. For Sta. 80 of above curve Deflection Angle = $.3 \times 27.62 \times 6.5 = 53.86'$. Also Deflection Angle = dfl. for 1 ft. from Table III $\times X = 1.95 \times 27.62 = 53.86'$. For Sta. 181 Deflection Angle = $53.86' + \frac{6^\circ 30'}{2} = 4^\circ 8.86'$.

Externals—From Table V for 1° curve, with central angle of $45^\circ 20'$, $E = 479.6$. Therefore, for $6^\circ 30'$ curve, $E = \frac{479.6}{6.5} + \text{Correction from Table VI} = 7.378 + .039 = 7.417$.

General Equations and Useful Data

	Symbol on Equation	Numerical Value
Area of circle	$\frac{\pi d^2}{4}$	
Area of Sector of Circle (Length of arc = l)	$1/2 lr$	
Area of Segment of Parabola (app.) (c = chord; m = mid. ord.)	$2/3 cm$	
Area of Segment of Circle	$2/3 cm$	
Cubic Feet in 1 Cubic Meter		35.3145
Cubic Inches in 1 Imperial Gallon		277.274
Cubic Inches in 1 U.S. Gallon		231
Feet in 1 Meter		3.2808
Feet in 1 Mile		5280
Gallons (Imperial) in 1 Cubic Foot		6.2321
Gallons (U.S.) in 1 Cubic Foot		7.48
Miles in 1 Kilometer		0.6213
Pounds (Av.) in 1 Kilogram		2.2046
Ratio of Circumference to Diameter	π	3.14159
Reciprocal of π		0.31831
Square Feet in 1 Acre		43,560
Volume of Sphere	$4/3 \pi r^3$	

Table I.—Minutes in Decimals of a Degree.

1'	.0167	11'	.1833	21'	.3500	31'	.5167	41'	.6833	51'	.8500
2	.0333	12	.2000	22	.3667	32	.5333	42	.7000	52	.8667
3	.0500	13	.2167	23	.3833	33	.5500	43	.7167	53	.8833
4	.0667	14	.2333	24	.4000	34	.5667	44	.7333	54	.9000
5	.0833	15	.2500	25	.4167	35	.5833	45	.7500	55	.9167
6	.1000	16	.2667	26	.4333	36	.6000	46	.7667	56	.9333
7	.1167	17	.2833	27	.4500	37	.6167	47	.7833	57	.9500
8	.1333	18	.3000	28	.4667	38	.6333	48	.8000	58	.9667
9	.1500	19	.3167	29	.4833	39	.6500	49	.8167	59	.9833
10	.1667	20	.3333	30	.5000	40	.6667	50	.8333	60	1.0000

Table II.—Inches in Decimals of a Foot.

$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{15}{16}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{8}$
.0052	.0078	.0104	.0156	.0208	.0260	.0313	.0417	.0521	.0625	.0729	.0833
1	2	3	4	5	6	7	8	9	10	11	12
.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167	1.0000

Table III.—Radii, Ordinates and Deflections

Deg.	Radius	Mid. Ord.	Tan Offset	Def. for 1 Foot	Deg.	Radius	Mid. Ord.	Tan Offset	Def. for 1 Foot
0° 10'	34377.5	.036	.145	0.05'	7°	819.02	1.528	6.105	2.10'
20	17188.8	.073	.291	0.10	20	781.84	1.600	6.395	2.20
30	11459.2	.109	.436	0.15	30	764.49	1.637	6.540	2.25
40	8594.42	.145	.582	0.20	40	747.89	1.673	6.685	2.30
50	6875.55	.182	.727	0.25					
1	5729.65	.218	.873	0.30	8	716.78	1.746	6.976	2.40
10	4911.15	.255	1.018	0.35	20	688.16	1.819	7.266	2.50
20	4297.28	.291	1.164	0.40	30	674.69	1.855	7.411	2.55
30	3819.83	.327	1.309	0.45	40	661.74	1.892	7.556	2.60
40	3437.87	.364	1.454	0.50					
50	3125.36	.400	1.600	0.55	9	637.28	1.965	7.846	2.70
					20	614.56	2.037	8.136	2.80
2	2864.93	.436	1.745	0.60	30	603.80	2.074	8.281	2.85
10	2644.58	.473	1.891	0.65	40	593.42	2.110	8.426	2.90
20	2455.70	.509	2.036	0.70					
30	2292.01	.545	2.181	0.75	10	573.69	2.183	8.716	3.00
40	2148.79	.582	2.327	0.80	20	546.44	2.292	9.150	3.15
50	2022.41	.618	2.472	0.85	30	521.67	2.402	9.585	3.30
					40	499.06	2.511	10.02	3.45
3	1910.08	.655	2.618	0.90	50	478.34	2.620	10.45	3.60
10	1809.57	.691	2.763	0.95	60	459.28	2.730	10.89	3.75
20	1719.12	.727	2.908	1.00	70	441.68	2.839	11.32	3.90
30	1637.28	.764	3.054	1.05	80	425.40	2.949	11.75	4.05
40	1562.88	.800	3.199	1.10	90	410.28	3.058	12.18	4.20
50	1494.95	.836	3.345	1.15	100	396.20	3.168	12.62	4.35
4	1432.69	.873	3.490	1.20	15	383.07	3.277	13.05	4.50
10	1375.40	.909	3.635	1.25	20	370.78	3.387	13.49	4.65
20	1322.53	.945	3.718	1.30	30	359.27	3.496	13.92	4.80
30	1273.57	.982	3.926	1.35	40	348.45	3.606	14.35	4.95
40	1228.11	1.018	4.071	1.40	50	338.27	3.716	14.78	5.10
50	1185.78	1.055	4.217	1.45	60	319.62	3.935	15.64	5.40
					70	302.94	4.155	16.51	5.70
5	1146.28	1.091	4.362	1.50	80	287.94	4.374	17.37	6.00
10	1109.33	1.127	4.507	1.55	90	274.37	4.594	18.22	6.30
20	1074.68	1.164	4.653	1.60	100	262.04	4.814	19.08	6.60
30	1042.14	1.200	4.798	1.65	110	250.79	5.035	19.94	6.90
40	1011.51	1.237	4.943	1.70	120	240.49	5.255	20.79	7.20
50	982.64	1.273	5.088	1.75					
6	955.37	1.309	5.234	1.80	130	231.01	5.476	21.64	7.50
10	929.57	1.346	5.379	1.85	140	222.27	5.697	22.50	7.80
20	905.13	1.382	5.524	1.90	150	214.18	5.918	23.35	8.10
30	881.95	1.418	5.669	1.95	160	206.68	6.139	24.19	8.40
40	859.92	1.455	5.814	2.00	170	199.70	6.360	25.04	8.70
					180	193.18	6.583	25.88	9.00

NOTE. Chord Deflection = 2 times tangent deflection.

Table IV.—Deflections for Sub Chords
for Short Radius Curves

Degree of Curve	Radius	Deflection Angles for Sub Chords of Various Lengths				Length of Arc for 100 Ft. Chord
		12.5 Ft.	15 Ft.	20 Ft.	25 Ft.	
30°	193.18	1° 51'	2° 17'	2° 58'	3° 43'	101.15
32°	181.39	1° 59'	2° 25'	3° 10'	3° 58'	101.33
34°	171.01	2° 06'	2° 33'	3° 21'	4° 12'	101.48
36°	161.80	2° 13'	2° 41'	3° 33'	4° 26'	101.66
38°	153.58	2° 20'	2° 49'	3° 44'	4° 40'	101.85
40°	146.19	2° 27'	2° 57'	3° 55'	4° 54'	102.06
42°	139.52	2° 34'	3° 05'	4° 07'	5° 08'	102.29
44°	133.47	2° 41'	3° 13'	4° 18'	5° 22'	102.53
46°	127.97	2° 48'	3° 21'	4° 29'	5° 36'	102.76
48°	122.92	2° 55'	3° 28'	4° 40'	5° 50'	103.00
50°	118.31	3° 02'	3° 38'	4° 51'	6° 04'	103.24
52°	114.06	3° 09'	3° 46'	5° 02'	6° 17'	103.54
54°	110.11	3° 16'	3° 54'	5° 13'	6° 31'	103.84
56°	106.50	3° 22'	4° 02'	5° 23'	6° 44'	104.14
58°	103.14	3° 29'	4° 10'	5° 34'	6° 57'	104.43
60°	100.00	3° 35'	4° 18'	5° 44'	7° 11'	104.72

Table V.—Tangents and External to a 1° Curve.

Central Angle	Tangent	External	Central Angle	Tangent	External	Central Angle	Tangent	External
1°			11°			21°		
10'	50.00	.22	10'	551.70	26.50	10'	1061.9	97.57
20	58.34	.30	20	560.11	27.31	20	1070.6	99.16
30	66.67	.39	30	568.53	28.14	30	1079.2	100.75
40	75.01	.49	40	576.95	28.97	40	1087.8	102.35
50	83.34	.61	50	585.36	29.82	50	1096.4	103.95
	91.68	.73		593.79	30.68		1105.1	105.60
2			12			22		
10	100.01	.87	10	602.21	31.56	10	1113.7	107.24
20	108.35	1.02	20	610.64	32.45	20	1122.4	108.90
30	116.68	1.19	30	619.07	33.35	30	1131.0	110.57
40	125.02	1.36	40	627.50	34.26	40	1139.7	112.25
50	133.36	1.55	50	635.93	35.18	50	1148.4	113.95
	141.70	1.75		644.37	36.12		1157.0	115.66
3			13			23		
10	150.04	1.96	10	652.81	37.07	10	1165.7	117.38
20	158.38	2.19	20	661.25	38.03	20	1174.4	119.12
30	166.72	2.43	30	669.70	39.01	30	1183.1	120.87
40	175.06	2.67	40	678.15	39.99	40	1191.8	122.63
50	183.40	2.93	50	686.60	40.99	50	1200.5	124.41
	191.74	3.21		695.06	42.00		1209.2	126.20
4			14			24		
10	200.08	3.49	10	703.51	43.03	10	1217.9	128.00
20	208.43	3.79	20	711.97	44.07	20	1226.6	129.82
30	216.77	4.10	30	720.44	45.12	30	1235.3	131.65
40	225.12	4.42	40	728.90	46.18	40	1244.0	133.50
50	233.47	4.76	50	737.37	47.25	50	1252.8	135.35
	241.81	5.10		745.85	48.34		1261.5	137.23
5			15			25		
10	250.16	5.46	10	754.32	49.44	10	1270.2	139.11
20	258.51	5.83	20	762.80	50.55	20	1279.0	141.01
30	266.86	6.21	30	771.29	51.68	30	1287.7	142.93
40	275.21	6.61	40	779.77	52.89	40	1296.5	144.85
50	283.57	7.01	50	788.26	53.97	50	1305.3	146.79
	291.92	7.43		796.75	55.13		1314.0	148.75
6			16			26		
10	300.28	7.86	10	805.25	56.31	10	1322.8	150.71
20	308.64	8.31	20	813.75	57.50	20	1331.6	152.69
30	316.99	8.76	30	822.25	58.70	30	1340.4	154.69
40	325.35	9.23	40	830.76	59.91	40	1349.2	156.70
50	333.71	9.71	50	839.27	61.14	50	1358.0	158.72
	342.08	10.20		847.78	62.38		1366.8	160.76
7			17			27		
10	350.44	10.71	10	856.30	63.63	10	1375.6	162.81
20	358.81	11.22	20	864.82	64.90	20	1384.4	164.86
30	367.17	11.75	30	873.35	66.18	30	1393.2	166.95
40	375.54	12.29	40	881.88	67.47	40	1402.0	169.04
50	383.91	12.85	50	890.41	68.77	50	1410.9	171.15
	392.28	13.41		898.95	70.09		1419.7	173.27
8			18			28		
10	400.66	13.99	10	907.49	71.42	10	1428.6	175.41
20	409.03	14.58	20	916.03	72.76	20	1437.4	177.55
30	417.41	15.18	30	924.58	74.12	30	1446.3	179.72
40	425.79	15.80	40	933.13	75.49	40	1455.1	181.89
50	434.17	16.43	50	941.69	76.86	50	1464.0	184.08
	442.55	17.07		950.25	78.26		1472.9	186.29
9			19			29		
10	450.93	17.72	10	958.81	79.67	10	1481.8	188.51
20	459.32	18.38	20	967.38	81.09	20	1490.7	190.74
30	467.71	19.06	30	975.96	82.53	30	1499.6	192.99
40	476.10	19.75	40	984.53	83.97	40	1508.5	195.25
50	484.49	20.45	50	993.12	85.43	50	1517.4	197.53
	492.88	21.16		1001.7	86.90		1526.3	199.82
10			20			30		
10	501.28	21.89	10	1010.3	88.39	10	1535.3	202.12
20	509.68	22.62	20	1018.9	89.89	20	1544.2	204.44
30	518.08	23.38	30	1027.5	91.40	30	1553.1	206.77
40	526.48	24.14	40	1036.1	92.92	40	1562.1	209.12
50	534.89	24.91	50	1044.7	94.46	50	1571.0	211.48
	543.29	25.70		1053.3	96.01		1580.0	213.86

Table V.—Tangents and External to a 1° Curve.

Central Angle	Tangent	External	Central Angle	Tangent	External	Central Angle	Tangent	External
31°			41°			51°		
10'	1589.0	216.3	10'	2142.2	387.4	10'	2732.9	618.4
20	1598.0	218.7	20	2151.7	390.7	20	2743.1	622.8
30	1606.9	221.1	30	2161.2	394.1	30	2753.4	627.2
40	1615.9	223.5	40	2170.8	397.4	40	2763.7	631.7
50	1624.9	226.0	50	2180.3	400.8	50	2773.9	636.2
	1633.9	228.4		2189.9	404.2		2784.2	640.7
32			42			52		
10	1643.0	230.9	10	2199.4	407.6	10	2794.5	645.2
20	1652.0	233.4	20	2209.0	411.1	20	2804.9	649.7
30	1661.0	235.9	30	2218.6	414.5	30	2815.2	654.3
40	1670.0	238.4	40	2228.1	418.0	40	2825.6	658.8
50	1679.1	241.0	50	2237.7	421.4	50	2835.9	663.4
	1688.1	243.5		2247.3	425.0		2846.3	668.0
33			43			53		
10	1697.2	246.1	10	2257.0	428.5	10	2856.7	672.7
20	1706.3	248.7	20	2266.6	432.0	20	2867.1	677.3
30	1715.3	251.3	30	2276.2	435.6	30	2877.5	682.0
40	1724.4	253.9	40	2285.9	439.2	40	2888.0	686.7
50	1733.5	256.5	50	2295.6	442.8	50	2898.4	691.4
	1742.6	259.1		2305.2	446.4		2908.9	696.1
34			44			54		
10	1751.7	261.8	10	2314.9	450.0	10	2919.4	700.9
20	1760.8	264.5	20	2324.6	453.6	20	2929.9	705.7
30	1770.0	267.2	30	2334.3	457.3	30	2940.4	710.5
40	1779.1	269.9	40	2344.1	461.0	40	2951.0	715.3
50	1788.2	272.6	50	2353.8	464.6	50	2961.5	720.1
	1797.4	275.3		2363.5	468.4		2972.1	725.0
35			45			55		
10	1806.6	278.1	10	2373.3	472.1	10	2982.7	729.9
20	1815.7	280.8	20	2383.1	475.8	20	2993.3	734.8
30	1824.9	283.6	30	2392.8	479.6	30	3003.9	739.7
40	1834.1	286.4	40	2402.6	483.8	40	3014.5	744.6
50	1843.3	289.2	50	2412.4	487.2	50	3025.2	749.6
	1852.5	292.0		2422.3	491.0		3035.8	754.6
36			46			56		
10	1861.7	294.9	10	2432.1	494.8	10	3046.5	759.6
20	1870.9	297.7	20	2441.9	498.7	20	3057.2	764.6
30	1880.1	300.6	30	2451.8	502.5	30	3067.9	769.7
40	1889.4	303.5	40	2461.7	506.4	40	3078.7	774.7
50	1898.6	306.4	50	2471.5	510.3	50	3089.4	779.8
	1907.9	309.3		2481.4	514.3		3100.2	784.9
37			47			57		
10	1917.1	312.2	10	2491.3	518.2	10	3110.9	790.1
20	1926.4	315.2	20	2501.2	522.2	20	3121.7	795.2
30	1935.7	318.1	30	2511.2	526.1	30	3132.6	800.4
40	1945.0	321.1	40	2521.1	530.1	40	3143.4	805.6
50	1954.3	324.1	50	2531.1	534.2	50	3154.2	810.9
	1963.6	327.1		2541.0	538.2		3165.1	816.1
38			48			58		
10	1972.9	330.2	10	2551.0	542.2	10	3176.0	821.4
20	1982.2	333.2	20	2561.0	546.3	20	3186.9	826.7
30	1991.5	336.3	30	2571.0	550.4	30	3197.8	832.0
40	2000.9	339.3	40	2581.0	554.5	40	3208.8	837.3
50	2010.2	342.4	50	2591.0	558.6	50	3219.7	842.7
	2019.6	345.5		2601.1	562.8		3230.7	848.1
39			49			59		
10	2029.0	348.6	10	2611.2	566.9	10	3241.7	853.5
20	2038.4	351.8	20	2621.2	571.1	20	3252.7	858.9
30	2047.8	354.9	30	2631.3	575.3	30	3263.7	864.3
40	2057.2	358.1	40	2641.4	579.5	40	3274.8	869.8
50	2066.6	361.3	50	2651.5	583.8	50	3285.8	875.3
	2076.0	364.5		2661.6	588.0		3296.9	880.8
40			50			60		
10	2085.4	367.7	10	2671.8	592.3	10	3308.0	886.4
20	2094.9	371.0	20	2681.9	596.6	20	3319.1	892.0
30	2104.3	374.2	30	2692.1	600.9	30	3330.3	897.5
40	2113.8	377.5	40	2702.3	605.3	40	3341.4	903.2
50	2123.3	380.8	50	2712.5	609.6	50	3352.6	908.8
	2132.7	384.1		2722.7	614.0		3363.8	914.5

Table V.—Tangents and Externals to a 1° Curve.

Central Angle	Tangent	External	Central Angle	Tangent	External	Central Angle	Tangent	External
61°	3375.0	920.2	71°	4086.9	1308.2	81°	4893.6	1805.3
10'	3386.3	925.9	10'	4099.5	1315.6	10'	4908.0	1814.7
20	3397.5	931.6	20	4112.1	1322.9	20	4922.5	1824.1
30	3408.8	937.3	30	4124.8	1330.3	30	4937.0	1833.6
40	3420.1	943.1	40	4137.4	1337.7	40	4951.5	1843.1
50	3431.4	948.9	50	4150.1	1345.1	50	4966.1	1852.6
62	3442.7	954.8	72	4162.8	1352.6	82	4980.7	1862.2
10	3454.1	960.6	10	4175.6	1360.1	10	4995.4	1871.8
20	3465.4	966.5	20	4188.5	1367.6	20	5010.0	1881.5
30	3476.8	972.4	30	4201.2	1375.2	30	5024.8	1891.2
40	3488.3	978.3	40	4214.0	1382.8	40	5039.5	1900.9
50	3499.7	984.3	50	4226.8	1390.4	50	5054.3	1910.7
63	3511.1	990.2	73	4239.7	1398.0	83	5069.2	1920.5
10	3522.6	996.2	10	4252.6	1405.7	10	5084.0	1930.4
20	3534.1	1002.3	20	4265.6	1413.5	20	5099.0	1940.3
30	3545.6	1008.3	30	4278.5	1421.2	30	5113.9	1950.3
40	3557.2	1014.4	40	4291.5	1429.0	40	5128.9	1960.2
50	3568.7	1020.5	50	4304.6	1436.8	50	5143.9	1970.3
64	3580.3	1026.6	74	4317.6	1444.6	84	5159.0	1980.4
10	3591.9	1032.8	10	4330.7	1452.5	10	5174.1	1990.5
20	3603.5	1039.0	20	4343.8	1460.4	20	5189.3	2000.6
30	3615.1	1045.2	30	4356.9	1468.4	30	5204.4	2010.8
40	3626.8	1051.4	40	4370.1	1476.4	40	5219.7	2021.1
50	3638.5	1057.7	50	4383.3	1484.4	50	5234.9	2031.4
65	3650.2	1063.9	75	4396.5	1492.4	85	5250.3	2041.7
10	3661.9	1070.2	10	4409.8	1500.5	10	5265.6	2052.1
20	3673.7	1076.6	20	4423.1	1508.6	20	5281.0	2062.5
30	3685.4	1082.9	30	4436.4	1516.7	30	5296.4	2073.0
40	3697.2	1089.3	40	4449.7	1524.9	40	5311.9	2083.5
50	3709.0	1095.7	50	4463.1	1533.1	50	5327.4	2094.1
66	3720.9	1102.2	76	4476.5	1541.4	86	5343.0	2104.7
10	3732.7	1108.6	10	4489.9	1549.7	10	5358.6	2115.3
20	3744.6	1115.1	20	4503.4	1558.0	20	5374.2	2126.0
30	3756.5	1121.7	30	4516.9	1566.3	30	5389.9	2136.7
40	3768.5	1128.2	40	4530.4	1574.7	40	5405.6	2147.5
50	3780.4	1134.8	50	4544.0	1583.1	50	5421.4	2158.4
67	3792.4	1141.4	77	4557.6	1591.6	87	5437.2	2169.2
10	3804.4	1148.0	10	4571.2	1600.1	10	5453.1	2180.2
20	3816.4	1154.7	20	4584.8	1608.6	20	5469.0	2191.1
30	3828.4	1161.3	30	4598.5	1617.1	30	5484.9	2202.2
40	3840.5	1168.1	40	4612.2	1625.7	40	5500.9	2213.2
50	3852.6	1174.8	50	4626.0	1634.4	50	5517.0	2224.3
68	3864.7	1181.6	78	4639.8	1643.0	88	5533.1	2235.5
10	3876.8	1188.4	10	4653.6	1651.7	10	5549.2	2246.7
20	3889.0	1195.2	20	4667.4	1660.5	20	5565.4	2258.0
30	3901.2	1202.0	30	4681.3	1669.2	30	5581.6	2269.3
40	3913.4	1208.9	40	4695.2	1678.1	40	5597.8	2280.6
50	3925.6	1215.8	50	4709.2	1686.9	50	5614.2	2292.0
69	3937.9	1222.7	79	4723.2	1695.8	89	5630.5	2303.5
10	3950.2	1229.7	10	4737.2	1704.7	10	5646.9	2315.0
20	3962.5	1236.7	20	4751.2	1713.7	20	5663.4	2326.6
30	3974.8	1243.7	30	4765.3	1722.7	30	5679.9	2338.2
40	3987.2	1250.8	40	4779.4	1731.7	40	5696.4	2349.8
50	3999.5	1257.9	50	4793.6	1740.8	50	5713.0	2361.5
70	4011.9	1265.0	80	4807.7	1749.9	90	5729.7	2373.3
10	4024.4	1272.1	10	4822.0	1759.0	10	5746.3	2385.1
20	4036.8	1279.3	20	4836.2	1768.2	20	5763.1	2397.0
30	4049.3	1286.5	30	4850.5	1777.4	30	5779.9	2408.9
40	4061.8	1293.6	40	4864.8	1786.7	40	5796.7	2420.9
50	4074.4	1300.9	50	4879.2	1796.0	50	5813.6	2432.9

Table V.—Tangents and Externals to a 1° Curve.

Central Angle	Tangent	External	Central Angle	Tangent	External	Central Angle	Tangent	External
91°	5830.5	2444.9	101°	6950.6	3278.1	111°	8336.7	4386.1
10'	5847.5	2457.1	10'	6971.3	3294.1	10'	8362.7	4407.6
20	5864.6	2469.3	20	6992.0	3310.1	20	8388.9	4429.2
30	5881.7	2481.5	30	7012.7	3326.1	30	8415.1	4450.9
40	5898.8	2493.8	40	7033.6	3342.3	40	8441.5	4472.7
50	5916.0	2506.1	50	7054.5	3358.5	50	8468.0	4494.6
92	5933.2	2518.5	102	7075.5	3374.9	112	8494.6	4516.6
10	5950.5	2531.0	10	7096.6	3391.2	10	8521.3	4538.8
20	5967.9	2543.5	20	7117.8	3407.7	20	8548.1	4561.1
30	5985.3	2556.0	30	7139.0	3424.3	30	8575.0	4583.4
40	6002.7	2568.6	40	7160.3	3440.9	40	8602.1	4606.0
50	6020.2	2581.3	50	7181.7	3457.6	50	8629.3	4628.6
93	6037.8	2594.0	103	7203.2	3474.4	113	8656.6	4651.3
10	6055.4	2606.8	10	7224.7	3491.3	10	8684.0	4674.2
20	6073.1	2619.7	20	7246.3	3508.2	20	8711.5	4697.2
30	6090.8	2632.6	30	7268.0	3525.2	30	8739.2	4720.3
40	6108.6	2645.5	40	7289.8	3542.4	40	8767.0	4743.6
50	6126.4	2658.5	50	7311.7	3559.6	50	8794.9	4766.9
94	6144.3	2671.6	104	7333.6	3576.8	114	8822.9	4790.4
10	6162.6	2684.7	10	7355.6	3594.2	10	8851.0	4814.1
20	6180.2	2697.9	20	7377.8	3611.7	20	8879.3	4837.8
30	6198.3	2711.2	30	7399.9	3629.2	30	8907.7	4861.7
40	6216.4	2724.5	40	7422.2	3646.8	40	8936.3	4885.7
50	6234.6	2737.9	50	7444.6	3664.5	50	8965.0	4909.9
95	6252.8	2751.3	105	7467.0	3682.3	115	8993.8	4934.1
10	6271.1	2764.8	10	7489.6	3700.2	10	9022.7	4958.6
20	6289.4	2778.3	20	7512.2	3718.2	20	9051.7	4983.1
30	6307.9	2792.0	30	7534.9	3736.2	30	9080.9	5007.8
40	6326.3	2805.6	40	7557.7	3754.4	40	9110.3	5032.6
50	6344.8	2819.4	50	7580.5	3772.6	50	9139.8	5057.6
96	6363.4	2833.2	106	7603.5	3791.0	116	9169.4	5082.7
10	6382.1	2847.0	10	7626.6	3809.4	10	9199.1	5107.9
20	6400.8	2861.0	20	7649.7	3827.9	20	9229.0	5133.3
30	6419.5	2875.0	30	7672.9	3846.5	30	9259.0	5158.8
40	6438.4	2889.0	40	7696.3	3865.2	40	9289.2	5184.5
50	6457.3	2903.1	50	7719.7	3884.0	50	9319.5	5210.3
97	6476.2	2917.3	107	7743.2	3902.9	117	9349.9	5236.2
10	6495.2	2931.6	10	7766.8	3921.9	10	9380.5	5262.3
20	6514.3	2945.9	20	7790.5	3940.9	20	9411.3	5288.6
30	6533.4	2960.3	30	7814.3	3960.1	30	9442.2	5315.0
40	6552.6	2974.7	40	7838.1	3979.4	40	9473.2	5341.5
50	6571.9	2989.2	50	7862.1	3998.7	50	9504.4	5368.2
98	6591.2	3003.8	108	7886.2	4018.2	118	9535.7	5395.1
10	6610.6	3018.4	10	7910.4	4037.8	10	9567.2	5422.1
20	6630.1	3033.1	20	7934.6	4057.4	20	9598.9	5449.2
30	6649.6	3047.9	30	7959.0	4077.2	30	9630.7	5476.5
40	6669.2	3062.8	40	7983.5	4097.1	40	9662.6	5504.0
50	6688.8	3077.7	50	8008.0	4117.0	50	9694.7	5531.7
99	6708.6	3092.7	109	8032.7	4137.1	119	9727.0	5559.4
10	6728.4	3107.7	10	8057.4	4157.3	10	9759.4	5587.4
20	6748.2	3122.9	20	8082.3	4177.5	20	9792.0	5615.5
30	6768.1	3138.1	30	8107.3	4197.9	30	9824.8	5643.8
40	6788.1	3153.3	40	8132.3	4218.4	40	9857.7	5672.3
50	6808.2	3168.7	50	8157.5	4239.0	50	9890.8	5700.9
100	6828.3	3184.1	110	8182.8	4259.7	120	9924.0	5729.7
10	6848.5	3199.6	10	8208.2	4280.5	10	9957.5	5758.6
20	6868.8	3215.1	20	8233.7	4301.4	20	9991.0	5787.7
30	6889.2	3230.8	30	8259.3	4322.4	30	10025.0	5817.0
40	6909.6	3246.5	40	8285.0	4343.6	40	10059.0	5846.5
50	6930.1	3262.3	50	8310.8	4364.8	50	10093.0	5876.1

Table VI.—Corrections for Tangents and Externals.

These corrections are to be added to the approximate values, found by dividing the tangent, or external, for a 1° curve (Table IV) by the degree of curve, in order to obtain the true tangents, or externals. Intermediate values may be obtained by interpolation.

FOR TANGENTS ADD

Central Angle	DEGREE OF CURVE													
	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
10°	.03	.06	.09	.13	.16	.19	.22	.25	.28	.31	.34	.38	.42	.46
15°	.04	.10	.14	.19	.24	.29	.34	.39	.45	.51	.53	.58	.63	.68
20°	.06	.13	.19	.26	.32	.39	.45	.51	.58	.65	.72	.79	.84	.90
25°	.08	.16	.24	.33	.40	.49	.58	.67	.75	.83	.90	.99	1.06	1.14
30°	.10	.19	.29	.39	.49	.59	.69	.79	.89	.99	1.09	1.20	1.29	1.39
35°	.11	.22	.34	.47	.58	.69	.81	.92	1.04	1.29	1.42	1.54	1.66	
40°	.13	.26	.40	.53	.67	.80	.93	1.06	1.20	1.34	1.49	1.64	1.79	1.94
45°	.15	.30	.44	.60	.76	.91	1.06	1.21	1.37	1.52	1.70	1.87	2.04	2.21
50°	.17	.34	.51	.68	.85	1.02	1.19	1.36	1.54	1.72	1.91	2.10	2.29	2.48
55°	.19	.38	.57	.76	.95	1.14	1.32	1.52	1.72	1.92	2.14	2.35	2.56	2.77
60°	.21	.42	.63	.84	1.05	1.27	1.49	1.71	1.94	2.17	2.38	2.60	2.83	3.07
65°	.23	.46	.69	.93	1.16	1.40	1.64	1.88	2.13	2.38	2.63	2.88	3.13	3.39
70°	.25	.51	.76	1.02	1.28	1.54	1.80	2.06	2.33	2.60	2.88	3.16	3.44	3.72
75°	.27	.56	.83	1.12	1.40	1.69	1.98	2.27	2.57	2.87	3.16	3.47	3.78	4.09
80°	.30	.61	1.01	1.22	1.53	1.84	2.15	2.46	2.78	3.10	3.44	3.78	4.12	4.46
85°	.33	.66	1.00	1.33	1.68	2.02	2.36	2.70	3.05	3.40	3.77	4.14	4.55	4.89
90°	.36	.72	1.09	1.45	1.83	2.20	2.57	2.94	3.32	3.70	4.10	4.50	4.91	5.32
95°	.39	.79	1.19	1.55	2.00	2.40	2.80	3.20	3.61	4.02	4.40	4.98	5.38	5.83
100°	.43	.86	1.30	1.74	2.18	2.62	3.06	3.50	3.95	4.40	4.88	5.37	5.85	6.34
110°	.51	1.03	1.56	2.08	2.61	3.14	3.67	4.21	4.76	5.31	5.86	6.43	7.01	7.60
120°	.62	1.25	1.93	2.52	3.16	3.81	4.45	5.11	5.77	6.44	7.12	7.80	8.50	9.22

FOR EXTERNALS ADD

Central Angle	DEGREE OF CURVE													
	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
10°	.001	.003	.004	.006	.007	.008	.009	.011	.012	.014	.015	.017	.018	.020
15°	.003	.007	.010	.014	.018	.023	.027	.029	.032	.035	.039	.043	.047	.051
20°	.006	.011	.017	.022	.028	.034	.038	.045	.051	.056	.063	.070	.076	.083
25°	.009	.018	.027	.036	.046	.056	.065	.074	.083	.093	.106	.120	.127	.135
30°	.013	.025	.038	.051	.065	.078	.090	.103	.116	.129	.149	.170	.179	.188
35°	.018	.035	.054	.072	.086	.109	.131	.153	.175	.197	.213	.230	.247	.264
40°	.023	.046	.070	.093	.117	.141	.172	.203	.234	.265	.277	.290	.315	.341
45°	.030	.060	.093	.119	.153	.184	.216	.254	.289	.325	.351	.378	.411	.445
50°	.037	.075	.116	.151	.189	.227	.266	.305	.345	.384	.425	.467	.508	.550
55°	.046	.093	.142	.188	.236	.283	.332	.381	.420	.479	.530	.582	.641	.700
60°	.056	.112	.168	.225	.283	.340	.398	.457	.516	.575	.636	.697	.774	.851
65°	.067	.135	.204	.273	.343	.412	.483	.554	.625	.697	.771	.845	.922	1.01
70°	.080	.159	.240	.321	.403	.485	.568	.652	.735	.819	.906	.994	1.08	1.17
75°	.095	.182	.286	.383	.480	.578	.678	.777	.877	.977	1.07	1.18	1.29	1.39
80°	.110	.220	.332	.445	.558	.671	.787	.903	1.02	1.13	1.25	1.38	1.50	1.62
85°	.128	.259	.391	.524	.657	.790	.926	1.06	1.20	1.34	1.47	1.62	1.76	1.91
90°	.149	.299	.450	.603	.756	.910	1.07	1.22	1.38	1.54	1.70	1.87	2.03	2.20
95°	.174	.350	.522	.706	.885	1.06	1.25	1.43	1.62	1.80	1.99	2.18	2.38	2.53
100°	.200	.401	.604	.809	1.01	1.22	1.43	1.64	1.85	2.06	2.28	2.50	2.73	2.96
110°	.268	.536	.806	1.08	1.35	1.63	1.91	2.20	2.48	2.76	3.05	3.35	3.66	3.96
120°	.360	.721	1.08	1.45	1.82	2.19	2.57	2.95	3.33	3.72	4.11	4.50	4.91	5.32

Table VII.—Corrections for Sub-Chords and Long Chords.

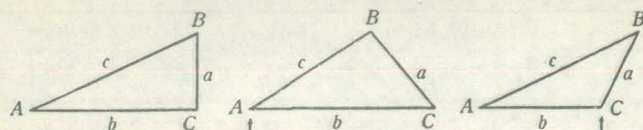
FOR SUB-CHORDS ADD											Excess of arc per 100 ft.	LONG CHORDS				
D	10	20	30	40	50	60	70	80	90	D		200	300	400	500	
4°	.00	.00	.01	.01	.01	.01	.01	.01	.00	.02	1	199.99	299.97	399.92	499.8	
6	.00	.01	.01	.02	.02	.02	.02	.01	.01	.05	2	199.97	299.88	399.70	499.39	
8	.01	.02	.02	.03	.03	.03	.03	.02	.01	.08	3	199.93	299.73	399.32	498.63	
10	.01	.02	.03	.04	.05	.05	.05	.04	.02	.13	4	199.88	299.51	398.78	497.57	
12	.02	.04	.05	.06	.07	.07	.07	.05	.03	.18	5	199.81	299.24	398.10	496.20	
14	.02	.05	.07	.08	.09	.10	.09	.07	.04	.25	6	199.73	298.90	397.26	494.53	
16	.03	.06	.09	.11	.12	.12	.12	.09	.05	.33	7	199.63	298.51	396.28	492.57	
18	.04	.08	.11	.14	.15	.16	.15	.12	.07	.41	8	199.51	298.05	395.14	490.31	
20	.05	.10	.14	.17	.19	.20	.18	.15	.09	.51	9	199.38	297.54	393.86	487.75	
22	.06	.12	.17	.21	.23	.24	.22	.18	.10	.62	10	199.24	296.96	392.42	484.90	
24	.07	.14	.20	.25	.28	.28	.26	.21	.12	.74	12	198.90	296.63	389.12	478.34	
26	.09	.17	.24	.29	.32	.33	.31	.25	.15	.86	14	198.51	294.06	385.22	470.65	
28	.10	.19	.27	.34	.37	.38	.36	.29	.17	1.00	16	198.05	292.25	380.76	461.86	
30	.11	.22	.31	.39	.43	.44	.41	.33	.19	1.15	18	197.54	290.21	375.74	452.02	
32	.13	.25	.36	.44	.49	.50	.47	.38	.22	1.31	20	196.90	287.94	370.17	441.15	
34	.15	.28	.40	.50	.55	.57	.53	.43	.25	1.48	22	196.32	285.44	364.06	429.30	
36	.17	.32	.45	.56	.62	.64	.59	.48	.28	1.66	24	195.63	282.71	357.43	416.53	
38	.18	.36	.51	.62	.70	.71	.66	.53	.31	1.86	26	194.87	279.76	350.30	402.82	
40	.21	.40	.56	.69	.77	.79	.73	.59	.35	2.06	28	194.06	276.59	342.69	388.42	
42	.23	.44	.62	.76	.85	.87	.81	.65	.38	2.28	30	193.18	273.20	334.61	373.20	
44	.25	.48	.68	.84	.94	.96	.89	.72	.42	2.50	32	192.25	269.63	326.08	357.28	
46	.27	.52	.75	.92	1.02	1.05	.98	.78	.46	2.74	34	191.26	265.81	317.12	340.73	
48	.30	.57	.81	1.00	1.12	1.14	1.06	.86	.50	2.99	36	190.21	261.80	307.77	323.61	
50	.32	.62	.89	1.09	1.21	1.24	1.15	.93	.55	3.24	38	189.10	257.60	298.03	305.99	
52	.35	.67	.96	1.18	1.31	1.35	1.25	1.01	.59	3.52	40	187.94	253.21	287.94	287.94	
54	.38	.73	1.04	1.28	1.42	1.46	1.35	1.09	.64	3.80	42	186.72	248.63	277.51	269.54	
56	.41	.78	1.12	1.38	1.53	1.57	1.46	1.17	.69	4.09	44	185.44	243.87	266.78	250.85	
58	.44	.84	1.20	1.48	1.65	1.69	1.57	1.20	.74	4.40	46	184.10	239.93	255.78	231.95	
60	.47	.91	1.29	1.59	1.76	1.81	1.68	1.35	.80	4.72	48	182.71	233.83	244.51	212.92	

NOTE.—When a chord of less than 100 ft. is used the corrections given in the above table should be added to the nominal length of chord to get the length which should be used in order that the 100 ft. points will check with those obtained by using the standard 100 ft. chord. Thus in locating a 14° curve by 25 ft. chords measure 25°.06 for each chord. Long chords are useful in passing obstacles.

Table VIII.—Middle Ordinates for Rails in Feet.

Deg. of Curve	LENGTH OF RAILS							Deg. of Curve	LENGTH OF RAILS						
	32	30	28	26	24	22	20		32	30	28	26	24	22	20
1°	.022	.020	.016	.013	.011	.009	.008	16°	.356	.313	.273	.236	.200	.170	.139
2	.045	.038	.034	.029	.025	.021	.017	17	.378	.333	.290	.252	.213	.180	.148
3	.067	.058	.051	.044	.037	.031	.026	18	.400	.351	.306	.265	.225	.190	.156
4	.089	.079	.069	.060	.050	.042	.035	19	.423	.371	.324	.280	.238	.201	.165
5	.112	.099	.086	.074	.063	.053	.044	20	.445	.392	.341	.296	.250	.212	.174
6	.134	.117	.102	.088	.076	.064	.052	21	.466	.410	.357	.309	.262	.222	.182
7	.156	.137	.120	.104	.088	.074	.061	22	.487	.430	.375	.325	.275	.233	.191
8	.179	.158	.137	.119	.100	.085	.070	23	.509	.450	.390	.338	.287	.243	.199
9	.201	.175	.153	.133	.112	.095	.078	24	.531	.469	.408	.354	.299	.253	.208
10	.223	.196	.171	.148	.125	.106	.087	25	.552	.486	.424	.367	.311	.263	.216
11	.245	.216	.188	.163	.139	.117	.096	26	.573	.506	.441	.382	.323	.274	.225
12	.268	.236	.206	.179	.151	.128	.105	27	.594	.524	.457	.396	.335	.284	.233
13	.290	.254	.222	.192	.163	.138	.113	28	.618	.545	.475	.411	.348	.294	.242
14	.312	.275	.239	.207	.175	.148	.122	29	.638	.564	.491	.424	.361	.303	.250
15	.334	.295	.257	.223	.188	.159	.131	30	.660	.583	.508	.438	.374	.313	.259

TRIGONOMETRIC FORMULÆ



Right Triangle

Oblique Triangles

Solution of Right Triangles

For Angle A. $\sin A = \frac{a}{c}$, $\cos A = \frac{b}{c}$, $\tan A = \frac{a}{b}$, $\cot A = \frac{b}{a}$, $\sec A = \frac{c}{a}$, $\csc A = \frac{c}{b}$

Given	Required	
a, b	A, B, c	$\tan A = \frac{a}{b}$, $\cot B = \frac{a}{b}$, $c = \sqrt{a^2 + b^2} = a \sqrt{1 + \frac{b^2}{a^2}}$
a, c	A, B, b	$\sin A = \frac{a}{c} = \cos B$, $b = \sqrt{(c+a)(c-a)} = c \sqrt{1 - \frac{a^2}{c^2}}$
A, a	B, b, c	$B = 90^\circ - A$, $b = a \cot A$, $c = \frac{a}{\sin A}$
A, b	B, a, c	$B = 90^\circ - A$, $a = b \tan A$, $c = \frac{b}{\cos A}$
A, c	B, a, b	$B = 90^\circ - A$, $a = c \sin A$, $b = c \cos A$

Solution of Oblique Triangles

Given	Required	
A, B, a	b, c, C	$b = \frac{a \sin B}{\sin A}$, $C = 180^\circ - (A+B)$, $c = \frac{a \sin C}{\sin A}$
A, a, b	B, c, C	$\sin B = \frac{b \sin A}{a}$, $C = 180^\circ - (A+B)$, $c = \frac{a \sin C}{\sin A}$
a, b, C	A, B, c	$A+B = 180^\circ - C$, $\tan \frac{1}{2}(A-B) = \frac{(a-b) \tan \frac{1}{2}(A+B)}{a+b}$
		$c = \frac{a \sin C}{\sin A}$
a, b, c	A, B, C	$s = \frac{a+b+c}{2}$, $\sin \frac{1}{2} A = \sqrt{\frac{(s-b)(s-c)}{bc}}$
		$\sin \frac{1}{2} B = \sqrt{\frac{(s-a)(s-c)}{ac}}$, $C = 180^\circ - (A+B)$
a, b, c	Area	$s = \frac{a+b+c}{2}$, $\text{area} = \sqrt{s(s-a)(s-b)(s-c)}$
A, b, c	Area	$\text{area} = \frac{bc \sin A}{2}$
A, B, C, a	Area	$\text{area} = \frac{a^2 \sin B \sin C}{2 \sin A}$

REDUCTION TO HORIZONTAL

Horizontal distance = slope distance multiplied by the cosine of the vertical angle. Thus, for a slope distance of 403.6 ft. and a vertical angle of $4^\circ 40'$ —the cosine of $4^\circ 40'$ taken from a table of natural trigonometrical functions, = .9967, and horizontal distance = $403.6 \times .9967 = 402.27$ ft.

Horizontal distance also = Slope distance minus slope distance times (1 - cosine of vertical angle). Using the same figures as in the preceding example—Cos $4^\circ 40' = .9967$, $1 - .9967 = .0033$, $403.6 \times .0033 = 1.33$ ft. Horizontal dist. = $403.6 - 1.33 = 402.27$ ft.

When the rise is known, the horizontal distance may be found by the following approximate rule—the slope distance less the square of the rise divided by twice the slope distance. Thus, for a slope distance of 372.5 ft., and a rise of 15 ft. the horizontal distance =

$$372.5 - \frac{15 \times 15}{2 \times 372.5} = 372.5 - .30 = 372.2 \text{ ft.}$$

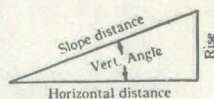


Table IX.—Natural Trigonometrical Functions.

Angle	Sin	Tan	Cot	Cos		Angle	Sin	Tan	Cot	Cos	
0°	0	0	∞	1	90	0°	0	0	∞	1	90
10	.0029	.0029	343.8	.9998	50	80	.1392	.1405	7.115	.99027	82
20	.0058	.0058	171.9	.9998	40	10	.1421	.1435	6.968	.98986	50
30	.0087	.0087	114.6	.9996	30	20	.1449	.1465	6.827	.98944	40
40	.0116	.0116	85.94	.9993	20	30	.1478	.1495	6.691	.98902	30
50	.0145	.0145	68.75	.9989	10	40	.1507	.1524	6.561	.98858	20
						50	.1536	.1554	6.435	.98814	10
1	.0175	.0175	57.29	.9985	89	9	.1564	.1584	6.314	.98769	81
10	.0204	.0204	49.10	.9979	50	10	.1593	.1614	6.197	.98723	50
20	.0233	.0233	42.96	.9973	40	20	.1622	.1644	6.084	.98676	40
30	.0262	.0262	38.19	.9966	30	30	.1650	.1673	5.976	.98629	30
40	.0291	.0291	34.37	.9958	20	40	.1679	.1703	5.871	.98580	20
50	.0320	.0320	31.24	.9949	10	50	.1708	.1733	5.769	.98531	10
2	.0349	.0349	28.64	.9939	88	10	.1736	.1763	5.671	.98481	80
10	.0378	.0378	26.43	.9929	50	10	.1765	.1793	5.576	.98430	50
20	.0407	.0407	24.54	.9917	40	20	.1794	.1823	5.485	.98378	40
30	.0436	.0437	22.90	.9905	30	30	.1822	.1853	5.396	.98325	30
40	.0465	.0466	21.47	.9892	20	40	.1851	.1883	5.309	.98272	20
50	.0494	.0495	20.21	.9878	10	50	.1880	.1914	5.226	.98218	10
3	.0523	.0524	19.08	.9863	87	11	.1908	.1944	5.145	.98163	79
10	.0552	.0553	18.07	.9847	50	10	.1937	.1974	5.066	.98107	50
20	.0581	.0582	17.17	.9831	40	20	.1965	.2004	4.989	.98050	40
30	.0610	.0612	16.35	.9813	30	30	.1994	.2035	4.915	.97992	30
40	.0640	.0641	15.60	.9795	20	40	.2022	.2065	4.843	.97934	20
50	.0669	.0670	14.92	.9776	10	50	.2051	.2095	4.773	.97875	10
4	.0698	.0699	14.30	.9756	86	12	.2079	.2126	4.705	.97815	78
10	.0727	.0729	13.73	.9736	50	10	.2108	.2156	4.638	.97754	50
20	.0756	.0758	13.20	.9714	40	20	.2136	.2186	4.574	.97692	40
30	.0785	.0787	12.71	.9692	30	30	.2164	.2217	4.511	.97630	30
40	.0814	.0816	12.25	.9668	20	40	.2193	.2247	4.449	.97566	20
50	.0843	.0846	11.83	.9644	10	50	.2221	.2278	4.390	.97502	10
5	.0872	.0875	11.43	.9619	85	13	.2250	.2309	4.331	.97437	77
10	.0901	.0904	11.06	.9594	50	10	.2278	.2339	4.275	.97371	50
20	.0929	.0934	10.71	.9567	40	20	.2306	.2370	4.219	.97304	40
30	.0958	.0963	10.39	.9540	30	30	.2334	.2401	4.165	.97237	30
40	.0987	.0992	10.08	.9511	20	40	.2363	.2432	4.113	.97169	20
50	.1016	.1022	9.788	.9482	10	50	.2391	.2462	4.061	.97100	10
6	.1045	.1051	9.514	.9452	84	14	.2419	.2493	4.011	.97030	76
10	.1074	.1080	9.255	.9421	50	10	.2447	.2524	3.962	.96959	50
20	.1103	.1110	9.010	.9390	40	20	.2476	.2555	3.914	.96887	40
30	.1132	.1139	8.777	.9357	30	30	.2504	.2586	3.867	.96815	30
40	.1161	.1169	8.556	.9324	20	40	.2532	.2617	3.821	.96742	20
50	.1190	.1198	8.345	.9290	10	50	.2560	.2648	3.776	.96667	10
7	.1219	.1228	8.144	.9255	83	15	.2588	.2679	3.732	.96593	75
10	.1248	.1257	7.953	.9221	50	10	.2616	.2711	3.689	.96517	50
20	.1276	.1287	7.770	.9182	40	20	.2644	.2742	3.647	.96440	40
30	.1305	.1317	7.596	.9144	30	30	.2672	.2773	3.606	.96363	30
40	.1334	.1346	7.429	.9106	20	40	.2700	.2805	3.566	.96285	20
50	.1363	.1376	7.269	.9067	10	50	.2728	.2836	3.526	.96206	10
	Cos	Cot	Tan	Sin	Angle		Cos	Cot	Tan	Sin	Angle

Table IX.—Natural Trigonometrical Functions.

Angle	Sin	Tan	Cot	Cos		Angle	Sin	Tan.	Cot	Cos	
o/ 16	.2756	.2867	3.487	.96126	74	o/ 24	.4067	.4452	2.246	.91355	66
10	.2784	.2899	3.450	.96046	50	10	.4094	.4487	2.229	.91236	50
20	.2812	.2931	3.412	.95964	40	20	.4120	.4522	2.211	.91116	40
30	.2840	.2962	3.376	.95882	30	30	.4147	.4557	2.194	.90996	30
40	.2868	.2994	3.340	.95799	20	40	.4173	.4592	2.177	.90875	20
50	.2896	.3026	3.305	.95715	10	50	.4200	.4628	2.161	.90753	10
17	.2924	.3057	3.271	.95630	73	25	.4226	.4663	2.145	.90631	65
10	.2952	.3089	3.237	.95545	50	10	.4253	.4699	2.128	.90507	50
20	.2979	.3121	3.204	.95459	40	20	.4279	.4734	2.112	.90383	40
30	.3007	.3153	3.172	.95372	30	30	.4305	.4770	2.097	.90259	30
40	.3035	.3185	3.140	.95284	20	40	.4331	.4806	2.081	.90133	20
50	.3062	.3217	3.108	.95195	10	50	.4358	.4841	2.066	.90007	10
18	.3090	.3249	3.078	.95106	72	26	.4384	.4877	2.050	.89879	64
10	.3118	.3281	3.048	.95015	50	10	.4410	.4913	2.035	.89752	50
20	.3145	.3314	3.018	.94924	40	20	.4436	.4950	2.020	.89623	40
30	.3173	.3346	2.989	.94832	30	30	.4462	.4986	2.006	.89493	30
40	.3201	.3378	2.960	.94740	20	40	.4488	.5022	1.991	.89363	20
50	.3228	.3411	2.932	.94646	10	50	.4514	.5059	1.977	.89232	10
19	.3256	.3443	2.904	.94552	71	27	.4540	.5095	1.963	.89101	63
10	.3283	.3476	2.877	.94457	50	10	.4566	.5132	1.949	.88968	50
20	.3311	.3508	2.850	.94361	40	20	.4592	.5169	1.935	.88835	40
30	.3338	.3541	2.824	.94264	30	30	.4617	.5206	1.921	.88701	30
40	.3365	.3574	2.798	.94167	20	40	.4643	.5243	1.907	.88566	20
50	.3393	.3607	2.773	.94068	10	50	.4669	.5280	1.894	.88431	10
20	.3420	.3640	2.747	.93969	70	28	.4695	.5317	1.881	.88295	62
10	.3448	.3673	2.723	.93869	50	10	.4720	.5354	1.868	.88158	50
20	.3475	.3706	2.699	.93769	40	20	.4746	.5392	1.855	.88020	40
30	.3502	.3739	2.675	.93667	30	30	.4772	.5430	1.842	.87882	30
40	.3529	.3772	2.651	.93565	20	40	.4797	.5467	1.829	.87743	20
50	.3557	.3805	2.628	.93462	10	50	.4823	.5505	1.816	.87603	10
21	.3584	.3839	2.605	.93358	69	29	.4848	.5543	1.804	.87462	61
10	.3611	.3872	2.583	.93253	50	10	.4874	.5581	1.792	.87321	50
20	.3638	.3906	2.560	.93148	40	20	.4899	.5619	1.780	.87178	40
30	.3665	.3939	2.539	.93042	30	30	.4924	.5658	1.767	.87036	30
40	.3692	.3973	2.517	.92935	20	40	.4950	.5696	1.756	.86892	20
50	.3719	.4006	2.496	.92827	10	50	.4975	.5735	1.744	.86748	10
22	.3746	.4040	2.475	.92718	68	30	.5000	.5774	1.732	.86603	60
10	.3773	.4074	2.455	.92609	50	10	.5025	.5812	1.720	.86457	50
20	.3800	.4108	2.434	.92499	40	20	.5050	.5851	1.709	.86310	40
30	.3827	.4142	2.414	.92388	30	30	.5075	.5890	1.698	.86163	30
40	.3854	.4176	2.394	.92276	20	40	.5100	.5930	1.686	.86015	20
50	.3881	.4210	2.375	.92164	10	50	.5125	.5969	1.675	.85866	10
23	.3907	.4245	2.356	.92050	67	31	.5150	.6009	1.664	.85717	59
10	.3934	.4279	2.337	.91936	50	10	.5175	.6048	1.653	.85567	50
20	.3961	.4314	2.318	.91822	40	20	.5200	.6088	1.643	.85416	40
30	.3987	.4348	2.300	.91706	30	30	.5225	.6128	1.632	.85264	30
40	.4014	.4383	2.282	.91590	20	40	.5250	.6168	1.621	.85112	20
50	.4041	.4417	2.264	.91472	10	50	.5275	.6208	1.611	.84959	10
	Cos	Cot	Tan.	Sin	Angle		Cos	Cot	Tan.	Sin	Angle

Table IX.—Natural Trigonometrical Functions.

Angle	Sin	Tan	Cot	Cos		Angle	Sin	Tan	Cot	Cos	
o/ 32	.5299	.6249	1.600	.84805	58	o/ 30	.6225	.7954	1.257	.78261	30
10	.5324	.6289	1.590	.84650	50	40	.6248	.8002	1.250	.78079	20
20	.5348	.6330	1.580	.84495	40	50	.6271	.8050	1.242	.77897	10
30	.5373	.6371	1.570	.84339	30	39	.6293	.8098	1.235	.77715	51
40	.5398	.6412	1.560	.84182	20	10	.6316	.8146	1.228	.77531	50
50	.5422	.6453	1.550	.84025	10	20	.6338	.8195	1.220	.77347	40
33	.5446	.6494	1.540	.83867	57	30	.6361	.8243	1.213	.77162	30
10	.5471	.6536	1.530	.83708	50	40	.6383	.8292	1.206	.76977	20
20	.5495	.6577	1.520	.83549	40	50	.6406	.8342	1.199	.76791	10
30	.5519	.6619	1.511	.83389	30	40	.6428	.8391	1.192	.76604	50
40	.5544	.6661	1.501	.83228	20	10	.6450	.8441	1.185	.76417	50
50	.5568	.6703	1.492	.83066	10	20	.6472	.8491	1.178	.76229	40
34	.5592	.6745	1.483	.82904	56	30	.6494	.8541	1.171	.76041	30
10	.5616	.6787	1.473	.82741	50	40	.6517	.8591	1.164	.75851	20
20	.5640	.6830	1.464	.82577	40	50	.6539	.8642	1.157	.75661	10
30	.5664	.6873	1.455	.82413	30	41	.6561	.8693	1.150	.75471	49
40	.5688	.6916	1.446	.82248	20	10	.6583	.8744	1.144	.75280	50
50	.5712	.6959	1.437	.82082	10	20	.6604	.8796	1.137	.75088	40
35	.5736	.7002	1.428	.81915	55	30	.6626	.8847	1.130	.74896	30
10	.5760	.7046	1.419	.81748	50	40	.6648	.8899	1.124	.74703	20
20	.5783	.7089	1.411	.81580	40	50	.6670	.8952	1.117	.74509	10
30	.5807	.7133	1.402	.81412	30	42	.6691	.9004	1.111	.74314	48
40	.5831	.7177	1.393	.81242	20	10	.6713	.9057	1.104	.74120	50
50	.5854	.7221	1.385	.81072	10	20	.6734	.9110	1.098	.73924	40
36	.5878	.7265	1.376	.80902	54	30	.6756	.9163	1.091	.73728	30
10	.5901	.7310	1.368	.80730	50	40	.6777	.9217	1.085	.73531	20
20	.5925	.7355	1.360	.80558	40	50	.6799	.9271	1.079	.73333	10
30	.5948	.7400	1.351	.80386	30	43	.6820	.9325	1.072	.73135	47
40	.5972	.7445	1.343	.80212	20	10	.6841	.9380	1.066	.72937	50
50	.5995	.7490	1.335	.80038	10	20	.6862	.9435	1.060	.72737	40
37	.6018	.7536	1.327	.79864	53	30	.6884	.9490	1.054	.72537	30
10	.6041	.7581	1.319	.79688	50	40	.6905	.9545	1.048	.72337	20
20	.6065	.7627	1.311	.79512	40	50	.6926	.9601	1.042	.72136	10
30	.6088	.7673	1.303	.79335	30	44	.6947	.9657	1.036	.71934	46
40	.6111	.7720	1.295	.79158	20	10	.6967	.9713	1.030	.71732	50
50	.6134	.7766	1.288	.78980	10	20	.6988	.9770	1.024	.71529	40
38	.6157	.7813	1.280	.78801	52	30	.7009	.9827	1.018	.71325	30
10	.6180	.7860	1.272	.78622	50	40	.7030	.9884	1.012	.71121	20
20	.6202	.7907	1.265	.78442	40	50	.7050	.9942	1.006	.70916	10
	Cos	Cot	Tan	Sin	Angle		Cos	Cot	Tan	Sin	Angle

STADIA REDUCTION DIAGRAM

Enter on the horizontal scale with the value of the stadia reading (the interval times the stadia constant) and run vertically upward to intersection with line representing the vertical angle. The location of this point with reference to the dotted lines marked "ONE" etc. gives the correction to be subtracted from the entering value, and to which " $f + c$ " (usually about 1 foot) must be added to obtain the true horizontal distance. The reading on the vertical scale plus about 0.1 ft. for each 5° of vertical angle [$(f + c) \sin \alpha$] is the true vertical distance.

If the vertical angle is beyond the range of diagram, use $H = R \cos^2 \alpha + 1$ to find true horizontal distance and $V = R \times \frac{1}{2} \sin 2\alpha$ for true vertical distance, where R equals observed stadia distance and α equals vertical angle.

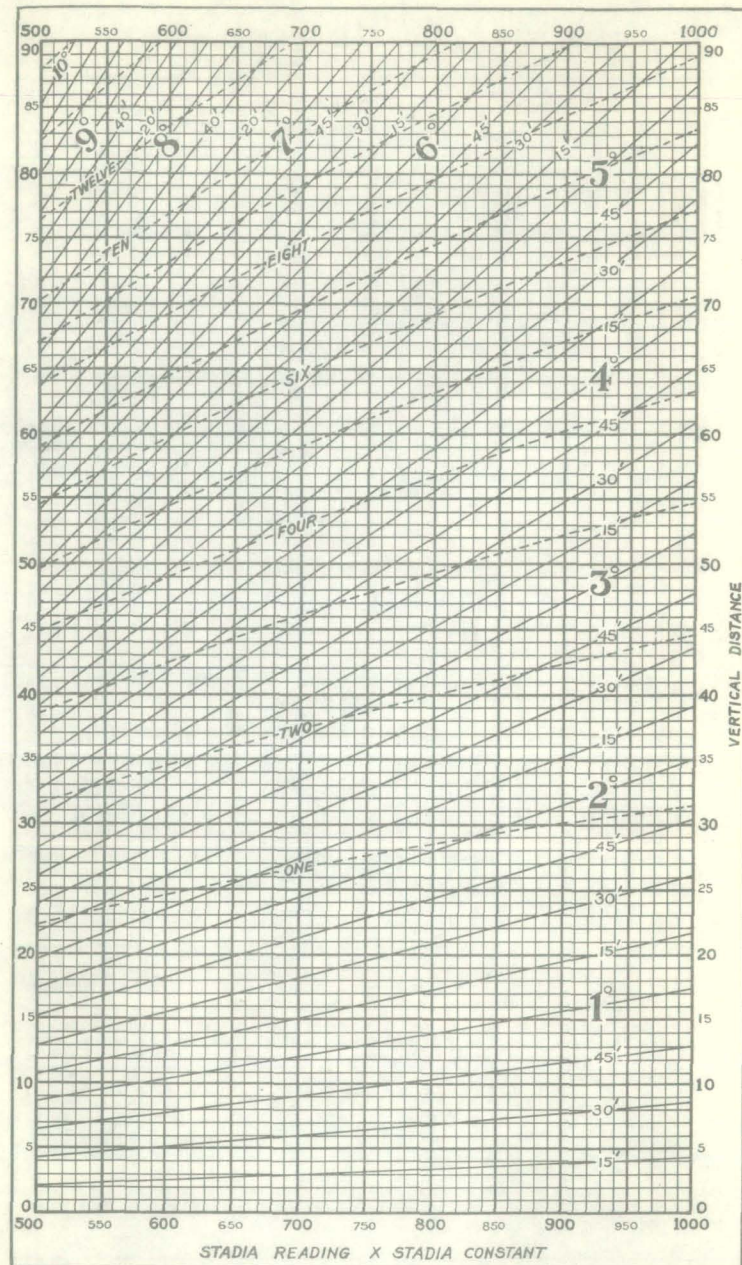
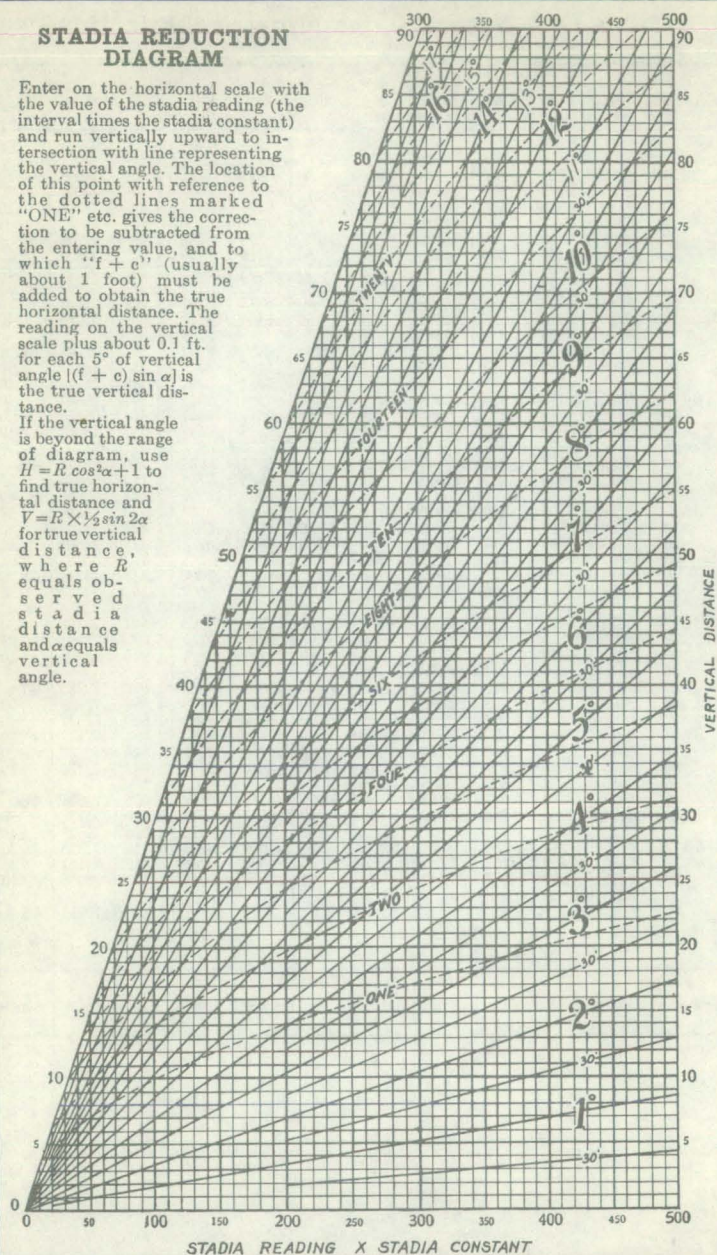


Table X.—Calculation of Earthwork.

Width	HEIGHT														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	.02	.04	.06	.07	.09	.11	.13	.15	.17	.18	.20	.22	.24	.26	.28
2	.04	.07	.11	.15	.18	.22	.26	.30	.33	.37	.41	.44	.48	.52	.56
3	.06	.11	.17	.22	.28	.33	.39	.44	.50	.56	.61	.67	.72	.78	.83
4	.07	.15	.22	.30	.37	.44	.52	.59	.67	.74	.81	.89	.96	1.04	1.11
5	.09	.19	.28	.37	.46	.56	.65	.74	.83	.93	1.02	1.11	1.20	1.30	1.39
6	.11	.22	.33	.44	.56	.67	.78	.89	1.00	1.11	1.22	1.33	1.44	1.55	1.67
7	.13	.26	.39	.52	.65	.78	.91	1.04	1.16	1.30	1.42	1.55	1.68	1.81	1.94
8	.15	.30	.44	.59	.74	.89	1.04	1.19	1.33	1.48	1.63	1.78	1.92	2.08	2.22
9	.17	.33	.50	.67	.83	1.00	1.17	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50
10	.18	.37	.56	.74	.93	1.11	1.30	1.48	1.67	1.85	2.04	2.22	2.41	2.59	2.78
11	.20	.41	.61	.82	1.02	1.22	1.43	1.63	1.83	2.04	2.24	2.44	2.65	2.85	3.06
12	.22	.44	.67	.89	1.11	1.33	1.56	1.78	2.00	2.22	2.44	2.67	2.89	3.11	3.33
13	.24	.48	.72	.96	1.20	1.44	1.68	1.92	2.16	2.41	2.65	2.89	3.13	3.37	3.61
14	.26	.52	.78	1.04	1.30	1.55	1.81	2.08	2.33	2.59	2.85	3.11	3.37	3.63	3.89
15	.28	.56	.83	1.11	1.39	1.67	1.94	2.22	2.50	2.78	3.06	3.33	3.61	3.89	4.17
16	.30	.59	.89	1.18	1.48	1.78	2.07	2.37	2.67	2.96	3.26	3.56	3.85	4.15	4.44
17	.31	.63	.94	1.26	1.57	1.89	2.20	2.52	2.83	3.15	3.46	3.78	4.09	4.41	4.72
18	.33	.67	1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00
19	.35	.70	1.06	1.41	1.76	2.11	2.46	2.82	3.17	3.52	3.87	4.22	4.57	4.92	5.28
20	.37	.74	1.11	1.48	1.85	2.22	2.59	2.96	3.33	3.70	4.07	4.44	4.81	5.18	5.56
21	.39	.78	1.17	1.55	1.94	2.33	2.72	3.11	3.50	3.89	4.28	4.67	5.06	5.44	5.83
22	.41	.81	1.22	1.63	2.04	2.44	2.85	3.26	3.67	4.07	4.48	4.89	5.30	5.70	6.11
23	.43	.85	1.28	1.70	2.13	2.56	2.98	3.41	3.83	4.26	4.68	5.11	5.54	5.96	6.39
24	.44	.89	1.33	1.78	2.22	2.67	3.11	3.56	4.00	4.44	4.89	5.33	5.78	6.22	6.67
25	.46	.92	1.39	1.85	2.31	2.78	3.24	3.70	4.17	4.63	5.09	5.56	6.02	6.48	6.94
26	.48	.96	1.44	1.92	2.41	2.89	3.37	3.85	4.33	4.82	5.30	5.78	6.26	6.74	7.24
27	.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50
28	.52	1.04	1.55	2.07	2.59	3.11	3.63	4.15	4.67	5.18	5.70	6.22	6.74	7.26	7.78
29	.54	1.07	1.61	2.15	2.68	3.22	3.76	4.30	4.83	5.37	5.91	6.44	6.98	7.52	8.06
30	.56	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5.00	5.55	6.11	6.67	7.22	7.78	8.33
31	.57	1.15	1.72	2.30	2.87	3.44	4.02	4.59	5.17	5.74	6.32	6.89	7.46	8.04	8.61
32	.59	1.18	1.78	2.37	2.96	3.56	4.15	4.74	5.33	5.92	6.52	7.11	7.70	8.30	8.89
33	.61	1.22	1.83	2.44	3.05	3.67	4.28	4.89	5.50	6.11	6.72	7.33	7.94	8.55	9.17
34	.63	1.26	1.89	2.52	3.15	3.78	4.40	5.04	5.67	6.29	6.93	7.56	8.18	8.81	9.44
35	.65	1.30	1.94	2.59	3.24	3.89	4.53	5.18	5.83	6.48	7.13	7.78	8.42	9.08	9.72
36	.67	1.33	2.00	2.67	3.33	4.00	4.66	5.33	6.00	6.67	7.33	8.00	8.67	9.33	10.00
37	.68	1.37	2.06	2.74	3.42	4.11	4.79	5.48	6.17	6.85	7.54	8.22	8.91	9.59	10.28
38	.70	1.41	2.11	2.82	3.52	4.22	4.92	5.63	6.33	7.03	7.74	8.44	9.15	9.85	10.56
39	.72	1.44	2.17	2.89	3.61	4.33	5.05	5.78	6.50	7.22	7.95	8.67	9.39	10.11	10.83
40	.74	1.48	2.22	2.96	3.70	4.44	5.18	5.92	6.67	7.41	8.15	8.89	9.63	10.37	11.11

Table X gives the number of cubic yards in a TRIANGLE 1 foot deep for a given width and height. CAUTION: Values obtained from the above tables are for only the one TRIANGLE of the cross-section under consideration.

Corrections for tenths of feet in width and height may be made by considering the numbers on the table from 1 to 9 as tenths and taking one tenth the values found in the tables. For example, to find the number of cubic yards when Width = W = 16.2 and Height = H = 5.3, opposite 16 in "Width" column and under 5 in the "Height" column read 1.48. To correct for additional 0.2 foot of width, opposite 2 in the "Width" column and under 5 in the "Height" column read 0.18 and correct to .018. To correct for additional 0.3 foot in height, under 3 in "Height" column and opposite 16 in "Width" column read 0.89 and correct to .089. Therefore, the total cubic yards in the given TRIANGLE for a depth of 1 foot = 1.48 + .018 + .089 = 1.587 or approximately 1.59 cu. yds. per 100 feet.

If width exceeds 40 feet, use one half real width and multiply result by 2. If both width and height are larger than values given on table use one half of each value and multiply result by 4.

